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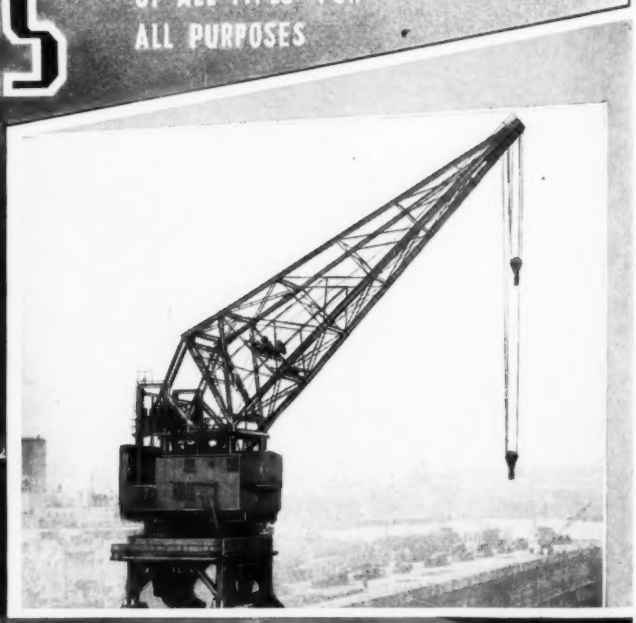

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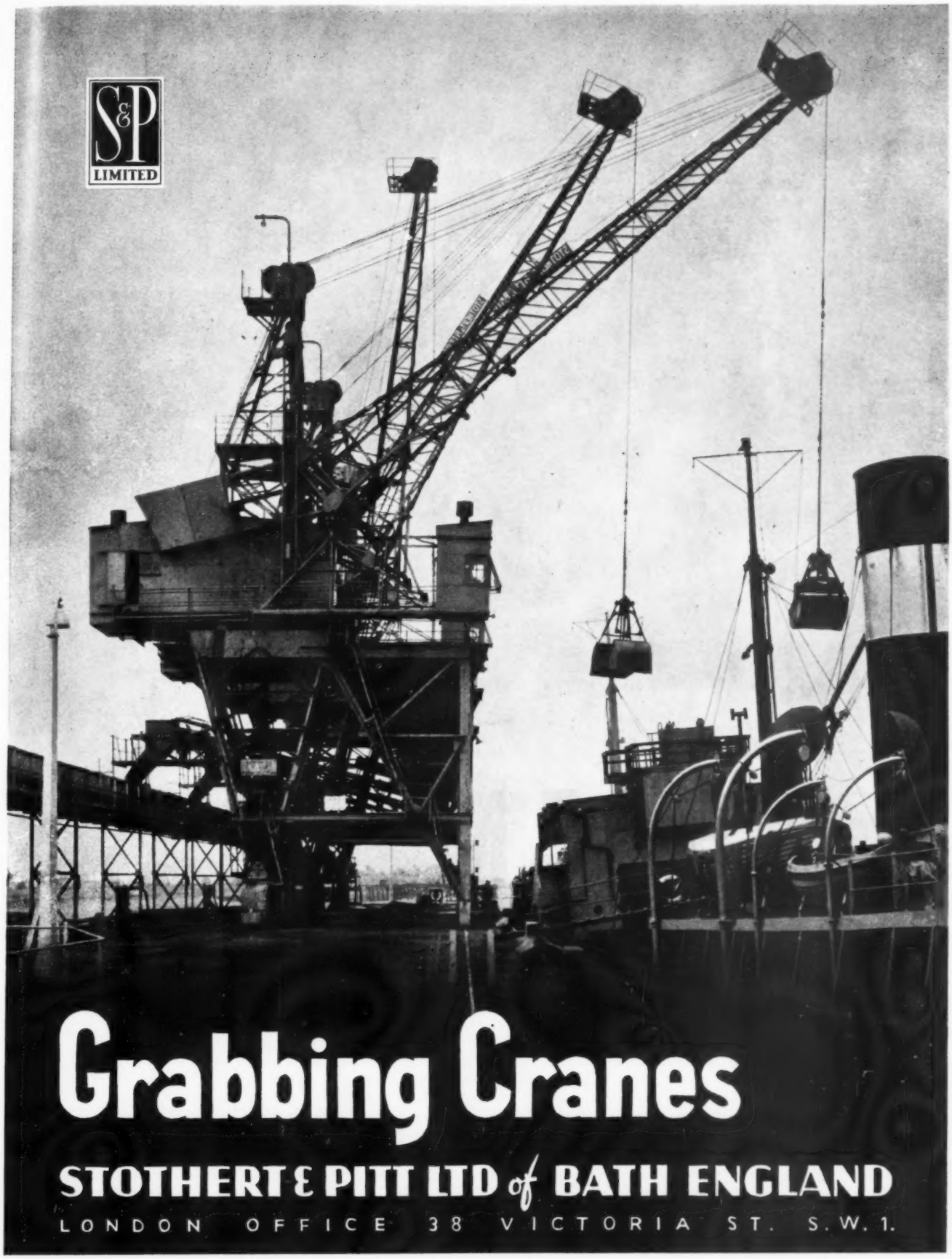
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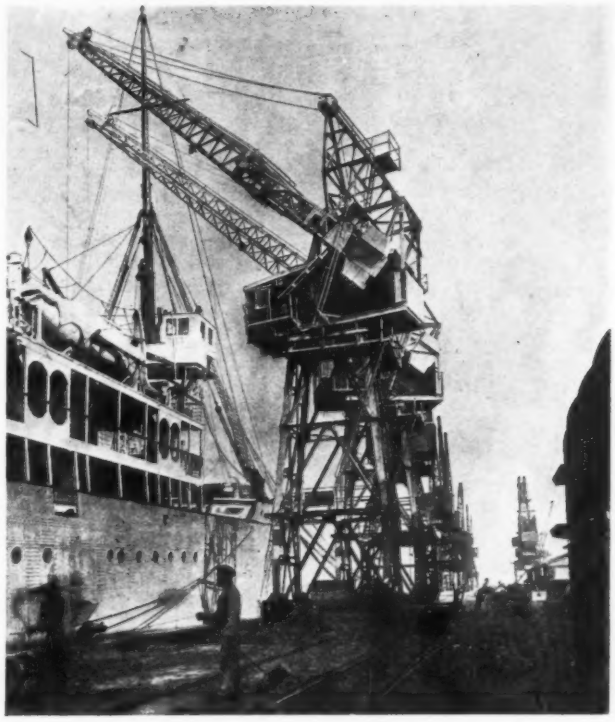

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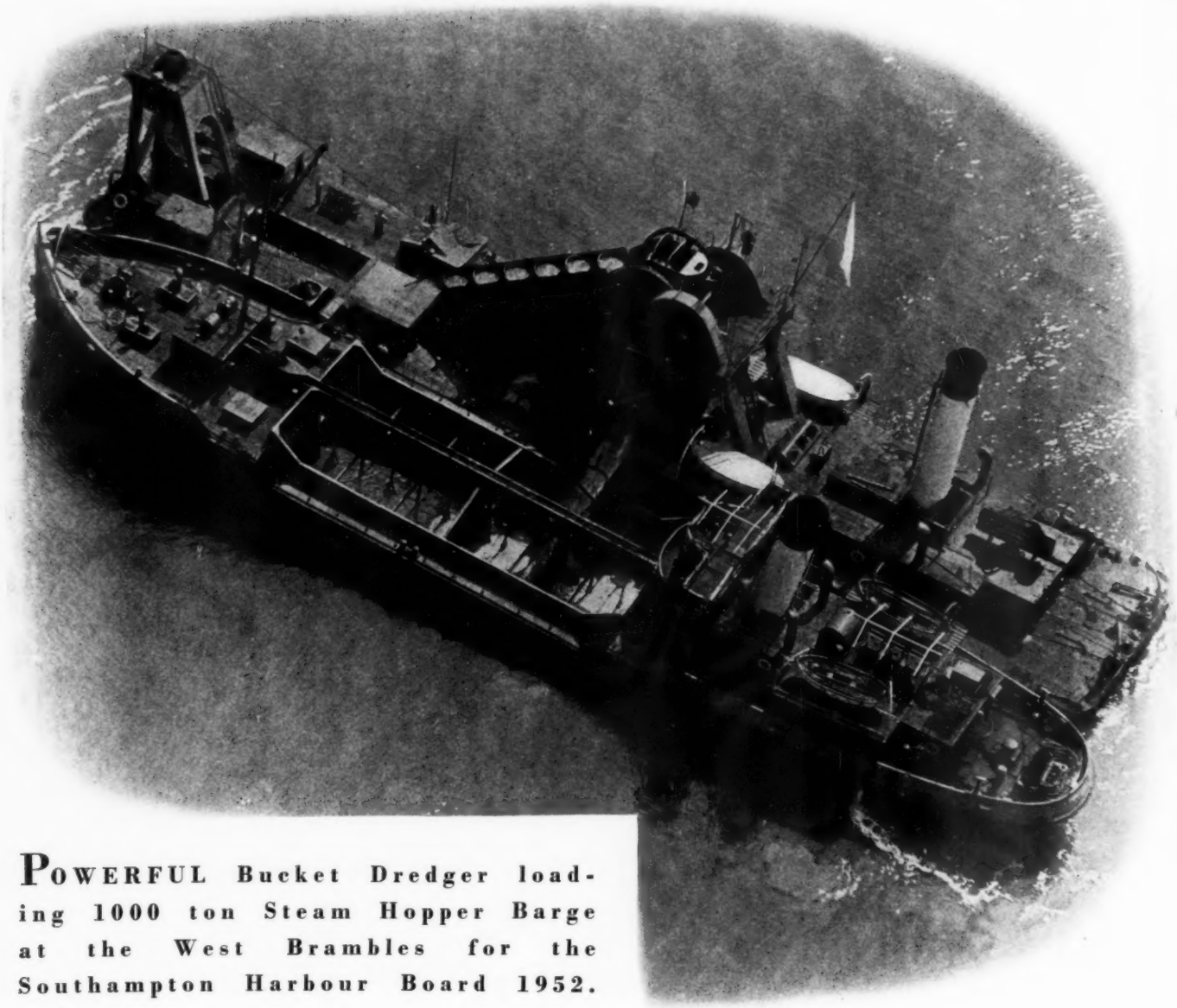

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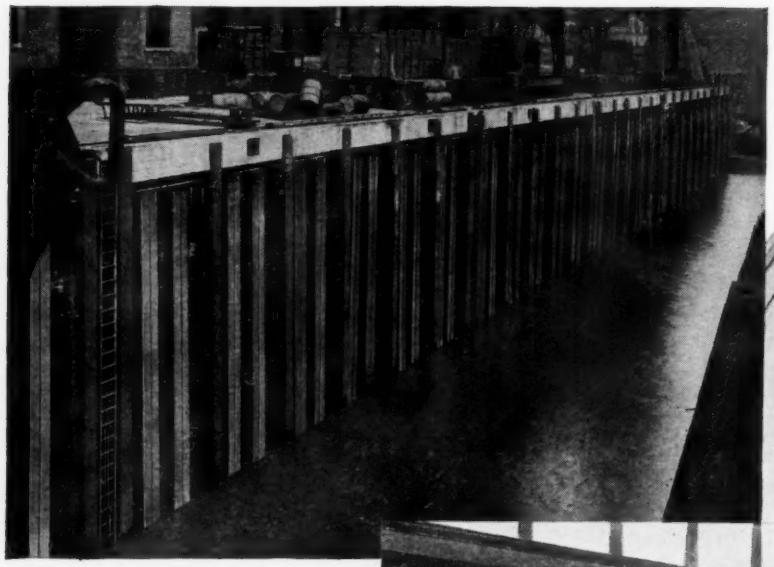

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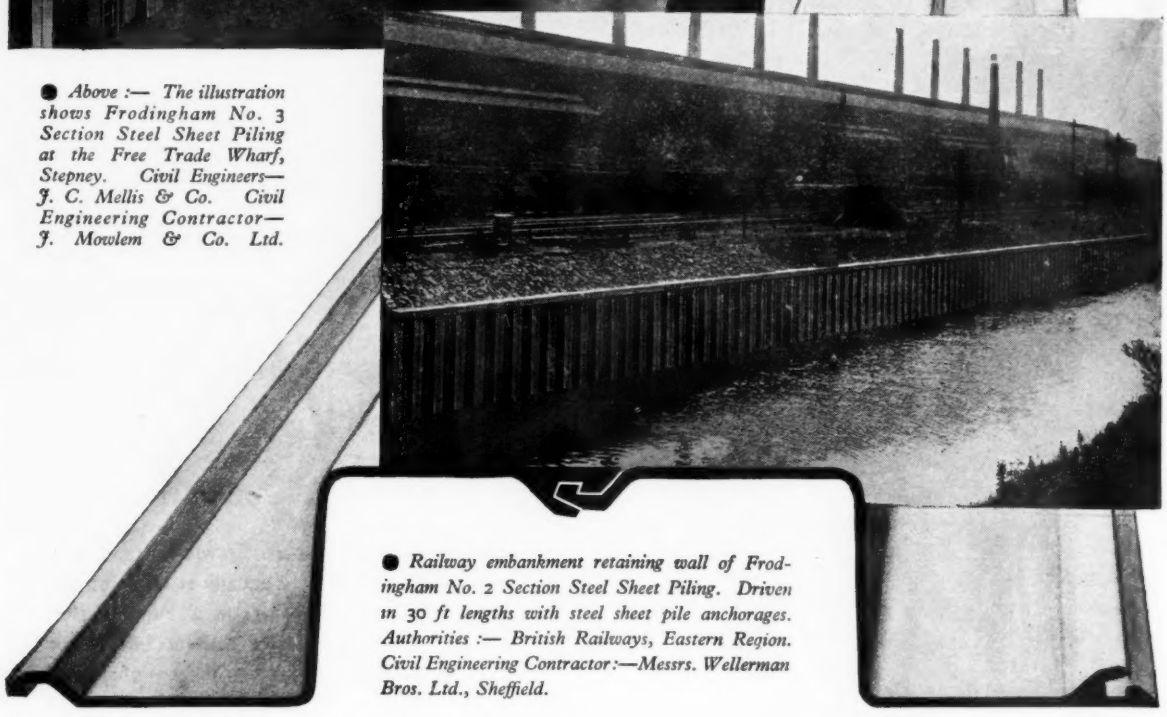

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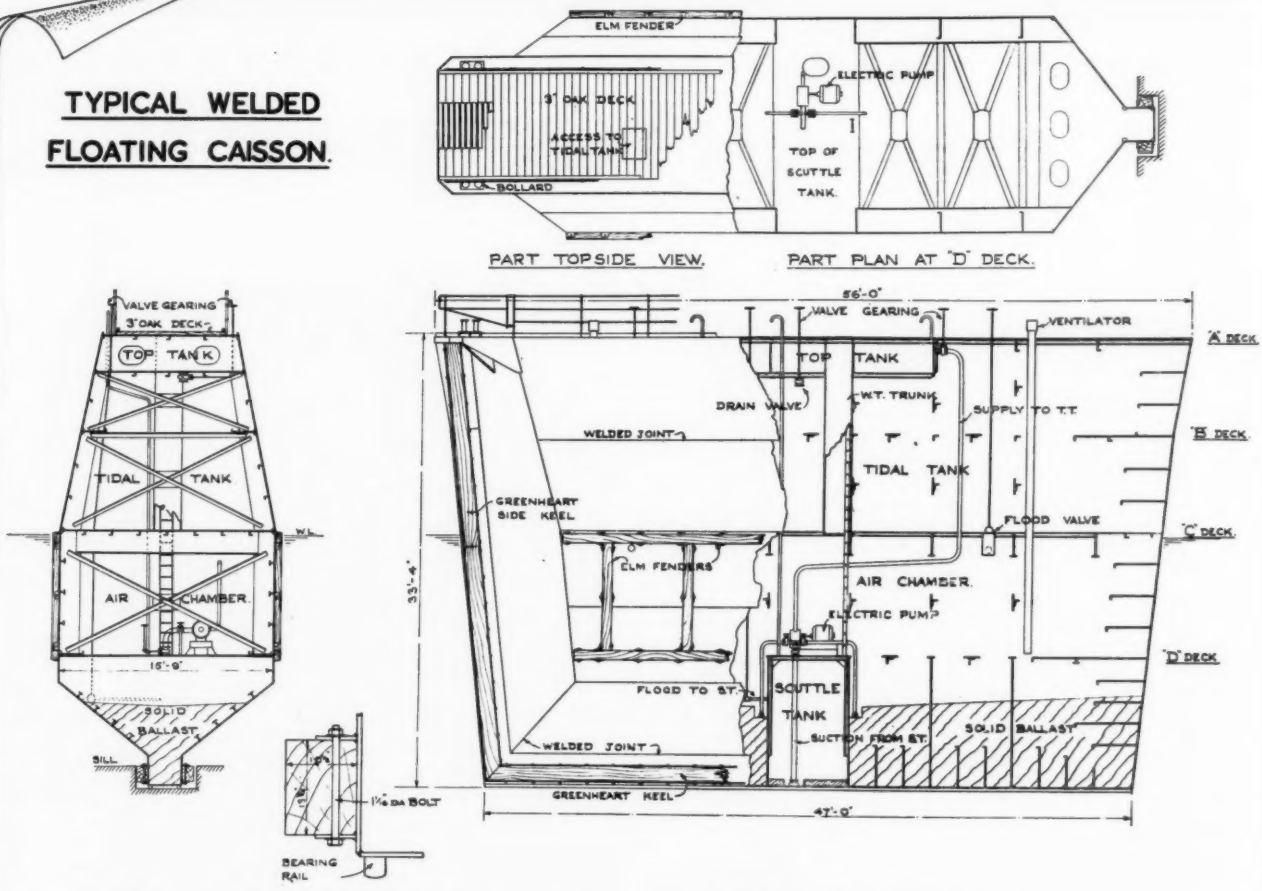

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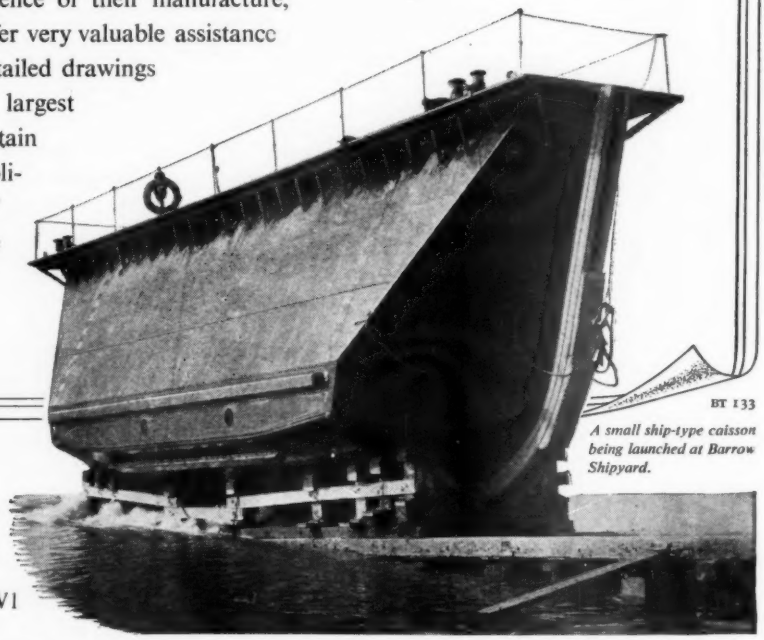

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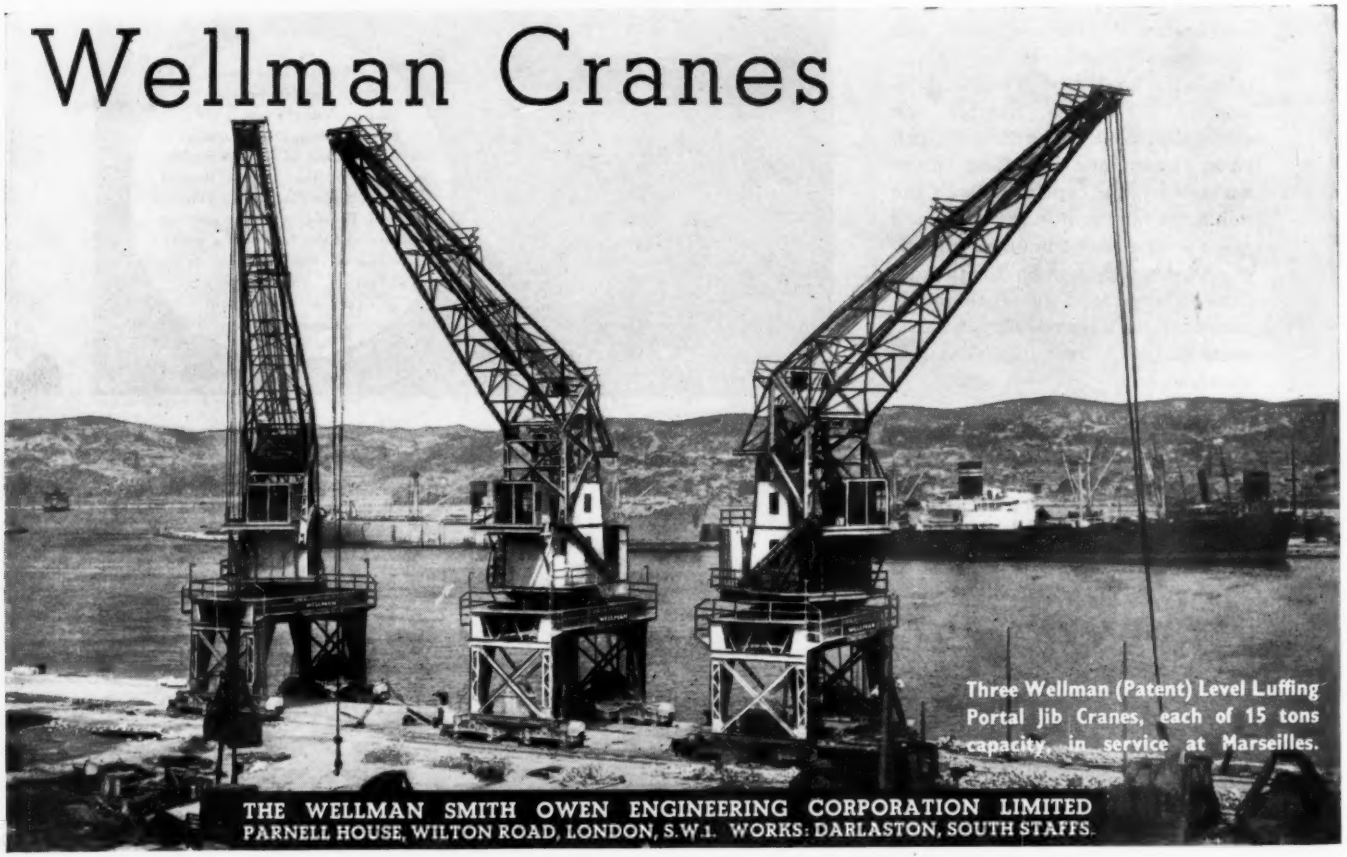

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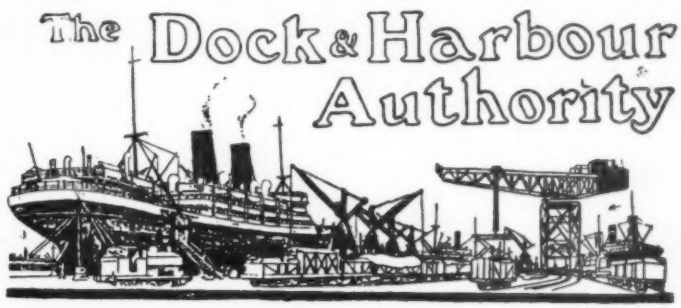

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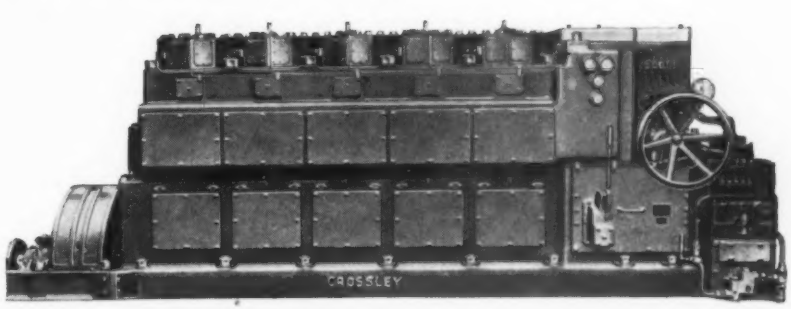

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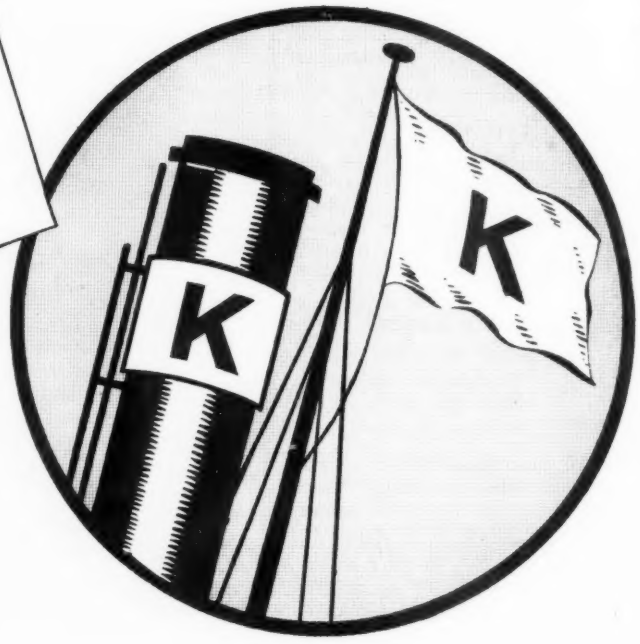

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The Dock and Harbour Authority

No. 382 Vol. XXXIII AUGUST, 1952 Monthly 2s. 0d

Editorial Comments

The Port of Stockholm.

The present year is the 700th anniversary of the foundation of the City of Stockholm which was inaugurated during the period when the Hanseatic League was a powerful organisation. Appropriately, therefore, to mark the event which is being duly celebrated in the City, Mr. Paul Leimdorfer of the Stockholm Harbour Board, has written a commemorative paper on the port, the first instalment of which forms our leading article this month.

The author's object was to present a paper from which everyone interested in port planning, dock and harbour engineering with its structural and traffic problems, cargo handling, or the import and export business, etc. would be able to obtain data and information. In this, our readers will agree, he has succeeded. In addition, it will be seen that an account is given of the Port's historical and geological background, together with a description of the evolution of the port facilities and improvements up to the present day, all of which aspects are of value when making a comparative port study.

Many items of interest will be found in the article, and among them, we would mention the very varied geological and sub-soil conditions met with in various areas in the harbour, and the special means that were adopted to provide stable foundations where great depths of soft clay were encountered. The development of wharf design and the modern constructional methods, especially those to be adopted in part of the Masthammen harbour, are of interest, as are also the form and details of the proposed new warehouses in various parts of the port.

The population of Stockholm has shown a spectacular increase during the past fourteen years, and now represents about one-sixth of the population of Sweden, and the area around the City is the most important centre of industrial production in the country.

With a view to meeting the increasing needs of the population and local industry, an enquiry was instituted some years ago, from which it was concluded that the capacity of the port should be considerably increased. Most of the recommendations have already been put in hand, while some have been completed. Among the finished works is the first stage of a new quay in the Masthammen harbour, the construction of which was described in detail in our December 1950 issue. Projected new works include extensive developments at the oil harbour at Loudden, where it is planned to provide larger and safer storage tanks in the rock. The blasting and cutting of these chambers is now proceeding.

The Stockholm Harbour Board is to be congratulated on the energy and enterprise with which it has carried out so many improvements during recent years, and we wish the City of Stockholm prosperity and success at this important stage in its long history.

Design Problems in Ship and Dock Construction.

An example of one of the problems confronting port authorities when making provision for possible increases in the size of vessels was brought to notice recently at the Port of Colombo, when at a meeting of the Commissioners, an enquiry was raised as to whether the Outer Graving Dock was large enough to accommodate the new 28,000-ton tankers that were being constructed. The Chairman replied that, so far as the length and the draft of the tankers were concerned, the Graving Dock was large enough; as however there was some doubt whether or not the dock width would have to be modified because of the moulded breadth of these vessels, the Shell Co. and Standard Vacuum Oil Co. had been asked to supply plans of this class of vessels to decide this point.

This Journal has frequently stressed the need for full collaboration and consultation between shipowners and port authorities before any new work either in shipbuilding or dock and harbour construction is undertaken. The benefits likely to accrue from adherence to this logical procedure should be obvious, as is amply indicated by the above example regarding the adequacy of the Colombo graving dock.

While port authorities almost invariably discuss with shipowners and masters the navigation aspects of new dock and harbour works there does not appear to be the same readiness on the part of shipowners to disclose shipbuilding proposals or to examine their possible repercussions on existing dock facilities. Dock works are becoming increasingly expensive and, as many facilities which have to be provided by port authorities are entirely unremunerative, any lack of co-operation is strongly to be deplored.

This need for consultation is the theme of a lecture delivered recently by Mr. John Anderson to a meeting of the Association of Navigation Schools in Aberdeen, details of which will be found on a following page, and we agree entirely with the emphasis with which Mr. Anderson has stressed the subject.

In Great Britain the wide range of the tides necessitates the provision of enclosed docks for the loading and discharge of most types of cargo, and one of the most pressing problems which dock and harbour authorities have to face is the increase in size of vessels. Ports have to be built on a long-term policy, whereas a ship can be scrapped and replaced after a life of little more than twenty years or so. It was Sir Rex Hodges, General Manager of the Mersey Docks and Harbour Board, who said in 1950 that " I do not know that ship designers sufficiently appreciate that ships are large contributors to the cost of building and maintaining the ports which serve them, and therefore that the additional cost of deepening and widening channels, dock entrances and the

Editorial Comments—continued

docks themselves largely falls on the running expenses of the ships which use them."

The assessment of the potential demands for new ships and additional port facilities, and the balancing of future requirements in terms of economy and efficiency, is a matter which should be resolved by the mutual agreement of all interests concerned.

The Sea Transport and Handling of Iron Ore.

The Report of the British Iron and Steel Productivity Team which visited the United States last year for the purpose of studying the steel industry of that country has recently been published.

While the Report naturally deals basically with the production of steel in all its aspects, the transport and handling of iron ores is necessarily an important part of the problem, and in this respect our readers will be interested in the observations of the team which are set out on a subsequent page.

It will be seen that the availability of ore ships has become a serious problem, and while special vessels are now being planned or are in course of building, were it not for inadequate port facilities, both in the United Kingdom and abroad, a number of ore-carriers of much larger size would have been ordered before. The Report states that, whereas American ports and ore-handling plants can deal with vessels of 22,500 tons, British ships have hitherto been restricted to 8,500 tons, but that vessels of 12-14,000 tons are now being built and larger ones are planned, but no information is given as to the ports which these larger vessels will serve.

It will be remembered that we reported, in our June 1951 issue, that investigations are being carried out by the British Iron and Steel Research Association regarding existing facilities and future possibilities of development at a number of British ports. In this connection, it is interesting to note that a new ore-discharging berth, to accommodate some of the projected larger vessels, is already in course of construction at the Bidston Dock, Birkenhead, as part of the steelworks development of John Summers and Sons, Ltd., Shotton, Cheshire.

The problems facing port authorities who are confronted with such large increases in the size of vessels have been remarked upon in the foregoing comment, and from the Report of the Productivity Team referred to above, it appears that agreement will also have to be reached regarding the ultimate dimensions of ore carriers. It is to be hoped that these problems will be settled on the basis of general, rather than sectional, interests.

Oil Pollution.

Increasing public attention in this country is being directed to the subject of oil pollution of our shores and coastal waters, and it has recently been announced that a series of observations on drifting oil are to be undertaken shortly.

Readers of this Journal will be well aware of the past events connected with the search for a solution of the problem, and the article which will be found on page 127 of this issue brings the position up to date. The proposed experiments which are mentioned in this article and are to be undertaken by three British oil tanker companies at their own expense, should provide some useful data regarding what ultimately happens to oil discharged at sea, which is a necessary step towards determining the areas from which oil refuse reaches our coasts.

It has been suggested that the Gulf Stream plays a part in bringing oil pollution to Great Britain, and there can be no doubt that prevailing winds and currents have considerable influence on oil drift. Likewise, it is probable that some of the increase in pollution during the past few years is caused by vessels, and particularly tankers, sunk during the recent war, but it certainly seems that most of the increase is due to the greater quantities of crude oil now being shipped to western European countries.

So far, no evidence appears to have been published concerning other countries which also suffer from oil pollution of their shores, neither has it been stated how far the present investigations, instituted by the Ministry of Transport in 1949, have proceeded.

Tank washing at sea is, more or less, a normal procedure, and while British vessels may take advantage of the facilities afforded at United Kingdom ports to avoid this, a glance at a map of the trade routes of the world will show what a large number of other vessels pass close to our shores. These craft may not be subject to any restrictions as to the discharge of bilge and tank washings, and this country has, at present, no control over them.

It is only by international legislation that oil pollution of maritime shores, wherever situated, can be safeguarded, and the recent assurance by the Minister of Transport, that he regards the solution of the problem as urgent, is therefore welcome. We trust that all the investigations now proceeding will speedily produce results so that recommendations may be submitted to the United Nations Organisation at an early date.

Bridge and Structural Engineering Congress.

The Fourth Congress of the International Association for Bridge and Structural Engineering is to be held in Cambridge and London from the 25th August to the 5th September next. The Opening Session will be held in Cambridge on the 25th August, followed by a Reception and Conversazione in the University Engineering Laboratories. Technical Sessions will take place from the 26th to the 29th August in the lecture theatres of the Engineering Department. The programme will also include visits to the Colleges and other places of interest in and around Cambridge.

On the 30th August members of the Congress will move to London where there will be a Government Reception, the Congress Dinner, and technical and sight-seeing tours. Three-day visits are also being arranged to South Wales and Scotland, from the 3rd to the 5th September.

Many dock and harbour engineers may be interested in further details concerning this Association, which was founded at Zurich in 1929 to promote "the interchange of knowledge, ideas, and the results of research work in the sphere of bridge and structural engineering whether in steel, reinforced concrete, or other material."

Meetings, or Congresses, are held every four years or so in different countries. Before these meetings, papers chosen for their interest and covering almost every aspect of the Association's work, from the testing of models to detailed descriptions of notable structures, are circulated in printed form. Subsequently, the papers are read and discussed at the meetings.

Individual membership is open to any person interested in bridge and structural engineering provided he belongs to a recognised scientific or technical society, or possesses the requisite knowledge. Collective membership is open to government or local authorities, scientific institutes, associations, syndicates, and firms.

To assist in the organisation of Congresses, and the submission of papers, membership is grouped nationally. The British group acts through an executive committee and information concerning membership can be obtained from the Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1.

The Shipping Turn-round Problem.

In the April issue of this Journal we referred in our editorial columns to reports from various sources on the vexed subject of slow turn-round of ships in port, and to the Government's intervention by the establishment of a Ports Efficiency Committee. The latest phase in attempting to solve the problem of turn-round is the establishment of two parallel bodies in each of the major ports (i.e.) a Port Operations Panel and a Port Users' Committee. Brief details concerning these bodies will be found elsewhere in this issue.

The London General Shipowners' Society in their annual report which was issued last month, refer to an appreciable all-round improvement in the turn-round of ships at the London docks, and call particular attention to the improvement in the overall rate of work in terms of cargo handled per gang hour. This is encouraging as far as it goes, but the problem is world-wide and conditions to-day are not quite the same as they were a few months ago. In several directions there are indications of a trade recession, and in the United Kingdom there is at the present time a surplus of dock labour. These two factors alone may be sufficient to ease the position temporarily, but the basic difficulties confronting port authorities, shipping companies and port users generally still remain to be solved.

The Port of Stockholm

A Leading Harbour of the Baltic

By PAUL LEIMDORFER of the Stockholm Harbour Board.

Historical.

OLD Stockholm commenced its life primarily as a fishing village. Its growth to a township is believed to have occurred in 1252, i.e. about half a century after the construction of the first stone London Bridge and is attributed to Birger Jarl (Eng.—" Earl Birger "). He was a son of King Valdemar and was the greatest nobleman of his time, who held a position similar to that of the Mayor of the Palace of the Franks in Merovingian times.

When Stockholm was founded the leadership in Baltic commerce was in the hand of the Hanseatic League. Consequently, from the middle of the 13th to the beginning of the 16th centuries great influence was exerted on Stockholm by the merchants of Danzig, Luebeck, Wismar, Rostock, Strahlsund, Stettin and others. Stockholm at this time resembled more a Hanseatic town than a prominent city of Sweden. The piracy prevalent in the Baltic also impeded the development of purely Swedish shipping and commerce. Having no fleet during this period, Sweden was unable to cope with these outside influences, which were felt until the beginning of the 16th century.

However, at the end of the 14th century the power of the Hanseatic League began to wane as a result of the union of Poland and Lithuania. This new state became one of the most powerful in Europe. Therefore, in 1466, the Germans were compelled to give up Danzig, which marked a turning point in the history of Swedish shipping. In 1507, after centuries of restriction, the first Swedish vessel left Stockholm for Riga, and more followed as time went on. Subsequently, protective regulations were made, prohibiting foreign ships from using certain harbours to the north and south of Stockholm (the so-called Baltic Trade Monopoly) thus indicating that it was intended to be the country's principal outlet to the Baltic. A new era for national trade was inaugurated with the coronation in 1523, of Gustavus Vasa as King of Sweden. The role of Sweden in European commerce and shipping increased even more during the reign of Gustavus Adolphus II (1611-1632), the grandson of Gustavus Vasa. This monarch revived the 16th century regulations requiring all vessels from the north of the Baltic to call and sell their cargoes at Stockholm. The part he played in the history of Stockholm is reminiscent, in many ways, of that played by Queen Elizabeth some decades earlier, in the development of London. In 1625, Söderkompaniet (Eng.- " The Southern Company ") was founded, with a view to trading with the whole world, using Swedish vessels. About 60 years after the British expedition of 1576 to Hudson's Bay, two ships, the " Kalmar Nyckel " (Eng.- " Key of Kalmar ") and the " Gripen " (Eng.- " The Grip ") were fitted out for a voyage to Delaware in North America, where a Swedish colony was founded in 1638. Although this enterprise lasted only 17 years, it resulted in the establishment of many permanent trade links with distant countries.

During succeeding centuries the importance of Stockholm increased, and it acquired numerous royal charters. In the period that elapsed until the end of the 19th century, the industrial expansion of the country as a whole was accompanied by an increase in population of the capital, which trebled from 100,000 to 300,000 during the years 1860-1900. This rise was accompanied by a corresponding increase in the size of the port, which at the present time is one of the largest, with the heaviest volume of traffic in the Baltic. The simultaneous economic and commercial expansion was accompanied by a greater demand for Swedish shipping, which led to the establishment of a number of shipping lines at the beginning of the present century. This trend continues at the present time. The population of the city now exceeds 750,000, while that of Greater Stockholm (i.e. including the immediate environs) is over 1,000,000, or one-seventh of the total population of the country. Stockholm, and the area adjacent to it, now constitutes one of the most important industrial regions of the country. The concentration of population, and hence of consumer markets, results in a continuing demand for increased port facilities.

Location.

Stockholm is located on latitude 59° 20″ north and on longitude 18° 3″ east, at a particularly favourable point, i.e. where Lake Mälar flows into the Baltic. The port is sheltered from heavy seas, gales and currents, since it is protected by an Archipelago of numerous islands and islets, with a width of about 27 nautical miles as the crow flies. The city comprises two zones on the mainland, one on the north and one on the south shore of Lake Mälar and a number of small and large islands in between. Here and there charming views are found of bays and small islands in the Baltic or Lake Mälar, and these with the numerous channels and canals evoke an atmosphere reminiscent of Venice.

Sea Approaches.

(a) From the North Sea to the Baltic.

Three main passages are available on this route: (1) through the Sound (Swedish- " Oeresund ") between Copenhagen and Malmö, where the depth of water is 26-ft., (2) through the Great

Fig. 1.

The Port of Stockholm—continued

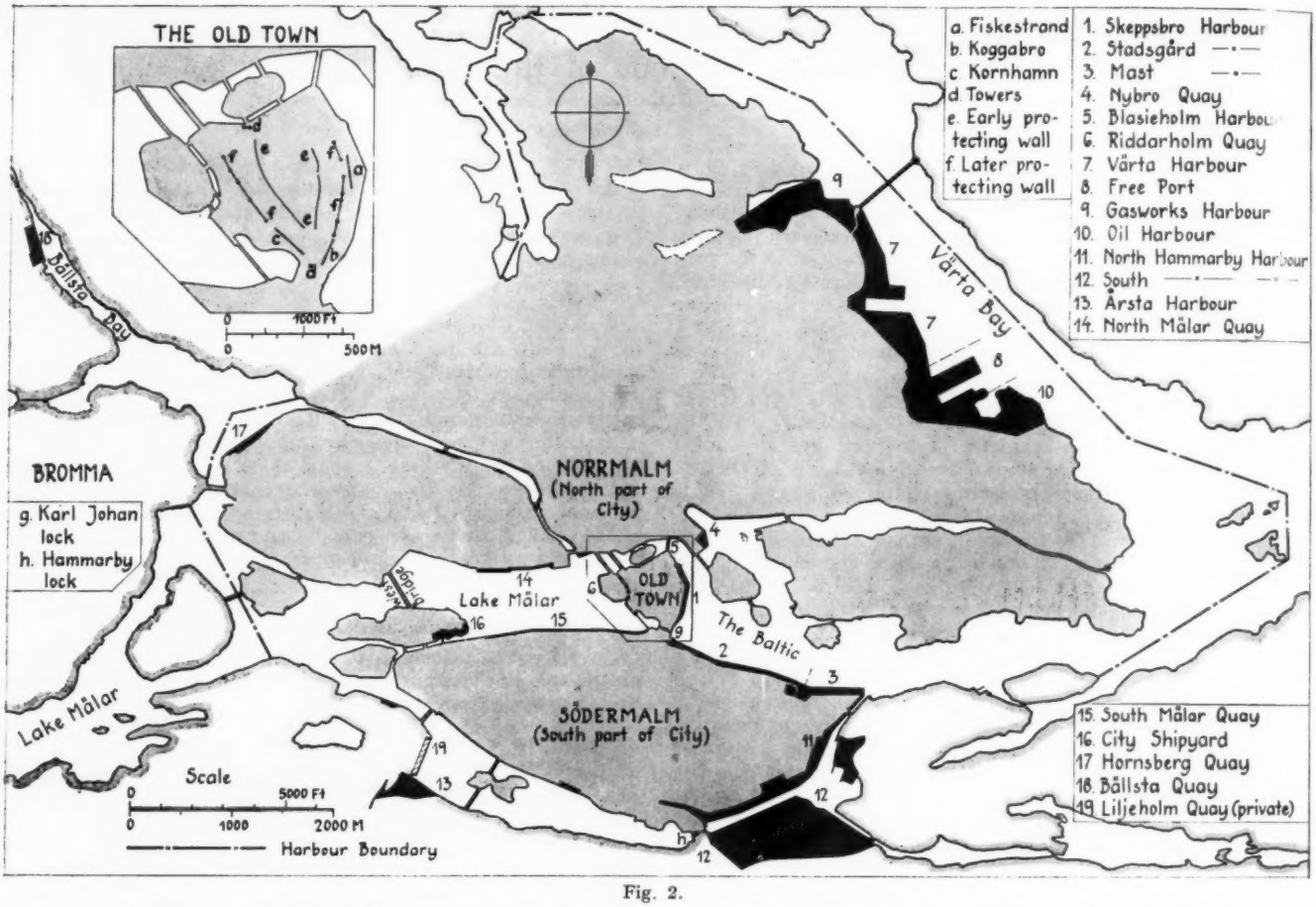


Fig. 2.

Belt—the channel between the Danish islands of Fyn and Sealand—where the water depth permits the passage of the biggest vessels of to-day, and (3) through the Kiel Canal, 53 nautical miles long. where the water is 37-ft. deep over a width of 144-ft. The free height above M.W. to the fixed bridges over the canal is 137-ft. On this last route, the passage takes about eight hours, and the maximum speed is limited to 8.1 knots. The maximum permitted draft of vessels using the canal is 31-ft., and a maximum mast height of 130-ft. above M.W. is allowed.

(B). From the Baltic to Stockholm. (See Fig. 1.)

Four principal approaches are available, viz. (1) from the south, through the Södertälje Canal, which has a total length of 51 nautical miles, and a minimum water depth of 19.5-ft. The canal itself extends for a length of two miles, and a has a depth of water of 23-ft. over a width of 79-ft., permitting the passage of vessels up to 18-ft. draught, lengths up to 394-ft. and beams up to 59-ft. No fixed bridges cross this canal which leads into Lake Mälar; (2) from the south through the Archipelago, past Landsort and Dalarö, with a total length of 77 nautical miles and a maximum permissible draught of 30-ft.; (3) from the east, via Sandhamn, with a total length of 36 nautical miles and a maximum permissible draught of 33-ft.; and (4) from the north, via Arholma and Söderarm, with a total length of 55 nautical miles, and a maximum permissible draught of 26-ft.

Inland Communications.

Apart from the direct route from the Baltic to Lake Mälar via the Södertälje Canal, mentioned above, the principal connection between the sea and the lake is through the Hammarby Canal, which was completed in 1930. This has a total length of about four miles, a minimum width of 115-ft. and a 20-ft. depth of water, i.e. the same as that in Lake Mälar. The Hammarby Lock can accommodate vessels up to 360-ft. long and with a maximum beam of 49-ft. (Fig. 2, h).

The third route from the Baltic to the Lake is through the Karl Johan Lock. This is rather small, however, and is limited to barges, motor boats, etc. (Fig. 2, g).

From Lake Mälar the heart of Sweden can be reached since the Mälar Valley is one of the most important industrial areas of the country. The lake is the third largest in Sweden, having a length of 70 nautical miles, and the navigable depth is 20-ft. From the lake, access is obtained to the hinterland through canals, i.e. to the south through the Hjälmare Canal, with a depth of 6-ft., and the Eskilstuna Canal (depth 7-ft. 6-in.), and to the north through the Strömsholm Canal (depth 4-ft. 5-in.); however, their importance is diminishing, as a result of the increased road traffic.

When navigating from the Baltic to the interior via Stockholm

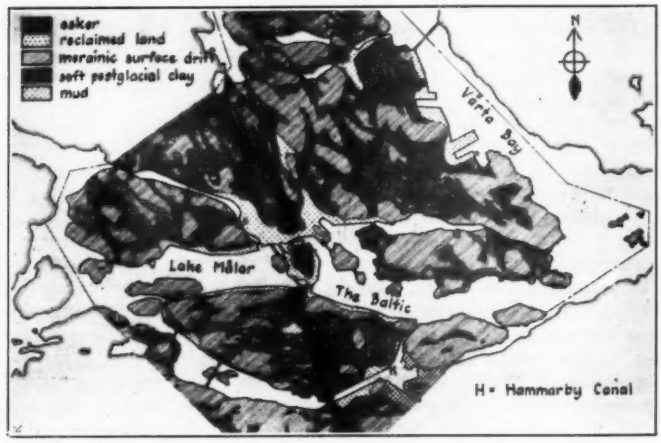


Fig. 3.

The Port of Stockholm—continued

and Lake Mälar, certain fixed bridges have to be passed. One is over the Hammarby Canal and allows a maximum mast height of 105-ft., while the other, at Västerbro (Eng.- " West Bridge ") limits the mast height to 78-ft. 6-in.

Sailing via the Södertälje Canal, it is possible to use another waterway into the interior, viz. the Göta Canal, which links the Baltic and the North Sea. This passes through a number of lakes, including the two largest in Sweden, the Vätter and the Väner, and terminates at Gothenburg, the second biggest city and the largest port in the country. This city, consequently, has a direct inland waterway to the capital. The Göta Canal can accommodate vessels with draughts up to 9-ft., lengths up to 105-ft., and widths up to 23-ft. The total distance between the Baltic and the Kattegat is about 210 nautical miles when using this canal.

Water Levels and Compositions.

Owing to the sheltered position, there are no currents of significance in the Port of Stockholm, and no tides. The differences between low and high water level in Baltic and the Mälar are 3-ft. and 2-ft. respectively.

The Mälar is a fresh water lake, while salt contents of the water on the Baltic side do not exceed 0.3 per cent. at the surface and 0.5 per cent. at the bottom. These advantageous circumstances facilitate harbour construction, and prolong the effective life of structures.

Land Emergence.

When dealing with the history of the port and the making of plans for new construction works or for dredging in the harbour, one has to consider the problem of land emergence. This phenomenon, which also occurs in North America, has been studied in great detail in Fennoscandia. It will be noted that, some 8,000 years ago, in northern Sweden the uplift of the land relative to the mean sea level amounted to as much as 3.5-in. per year, whilst in the Stockholm area it reached about 0.3-in. per year.

Extensive investigations at the turn of the century demonstrated that the major part of the Fennoscandian uplift is due to isostatic movements of the earth's crust, and thus is brought about by recovery of the land following the removal of the large ice sheets at the end of the glacial epoch.

The rate of uplift has varied in historical times. At present, in Stockholm, it is about 15-in. per century and it seems probable that the rate will decrease gradually and cease after another 18,000 years.

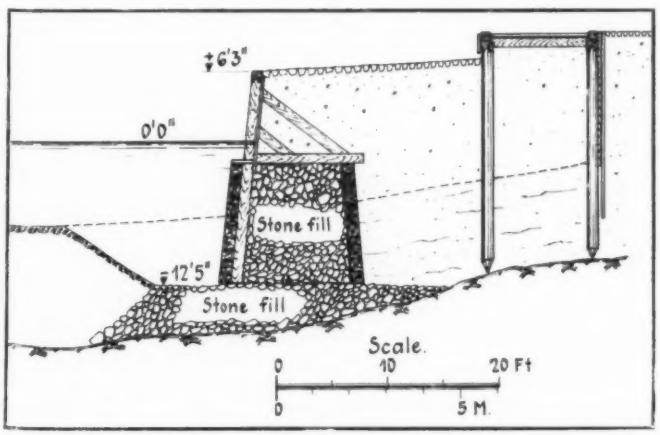


Fig. 5.

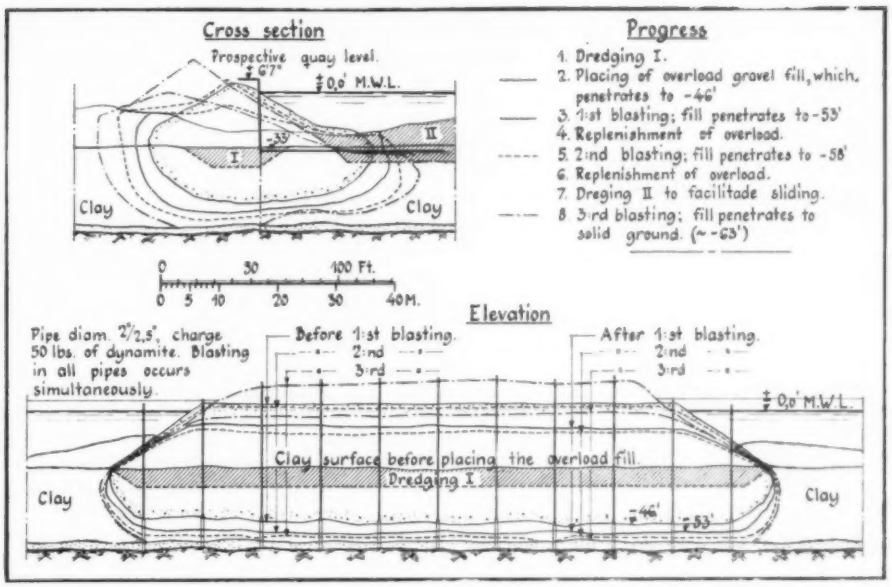


Fig. 4.

DEVELOPMENT OF THE HARBOURS (Fig. 2)

(A). Skeppsbro Harbour.

The first harbour in the old town of Stockholm was constructed on the seaward side of The Town Island (Stadsholmen) often called the City between the Bridges, during the 13th century, and was the so-called " Fiskestrand " (Eng.- " Fisherman's shore "), which was first referred to in 1408. It consisted of a simple wooden jetty, built on timber piles. The length was about 260-ft., the width 8-ft. to 10-ft., and the diameter and length of the piles were 10-in. to 12-in. and 20-ft. respectively. A breakwater of the same type of construction was built off this primitive jetty, the whole serving principally as a fishing harbour.

The enlargement of the Fiskestrand harbour comprised the Koggabro (Eng.- " Navy Bridge "), and simultaneously on the Mälar side, the so-called Kornhamn (Eng.- " Corn Harbour ").

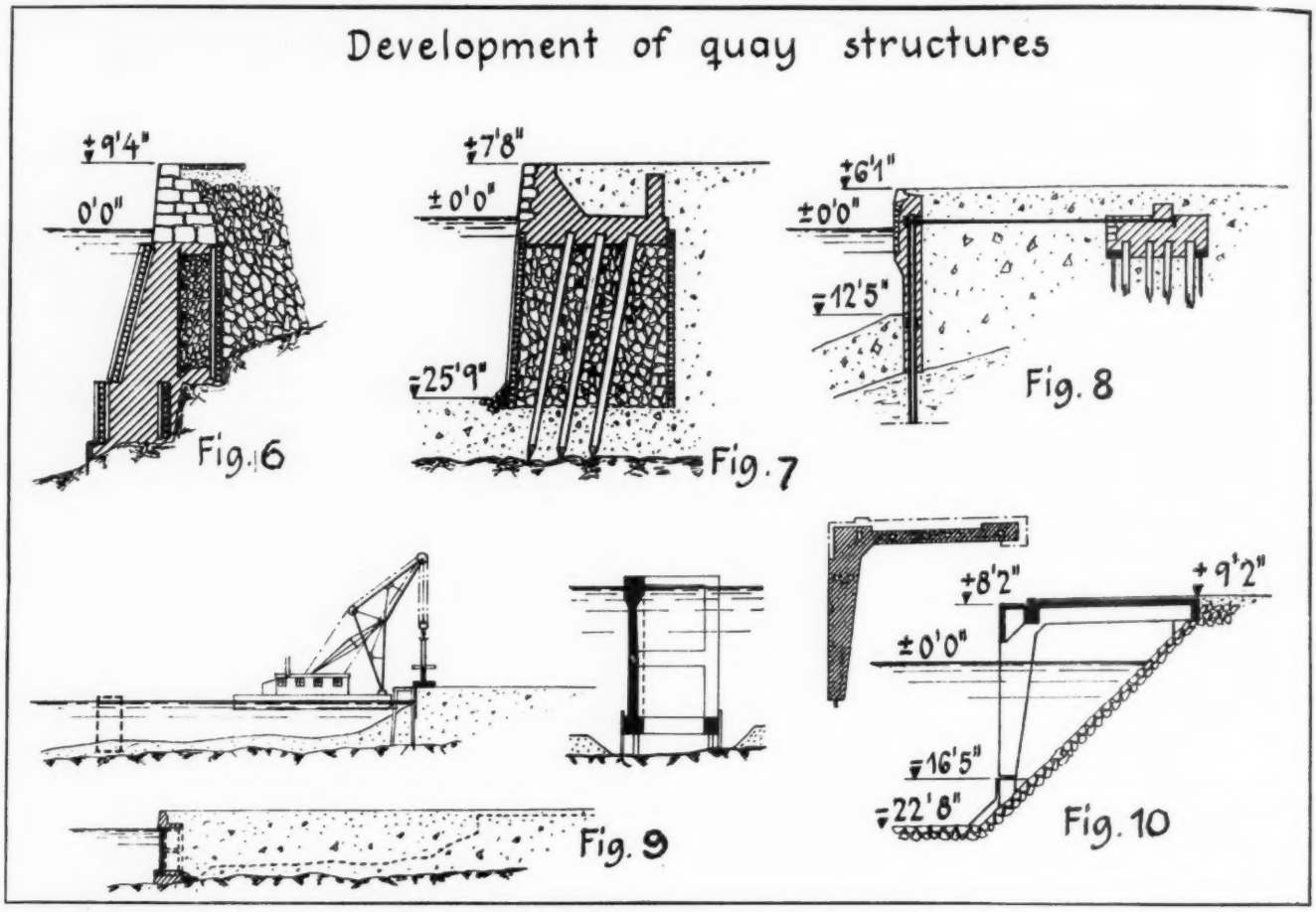
During the 16th and 17th centuries a number of other jetties were erected round the Town Island, and substantial wooden fenders were added to the older structures. The new jetties were generally located outside the mediæval system of fortifications. This consisted of two main towers, which were eventually connected by a circular wall enclosing the whole island. To protect the older harbours, which constituted a vulnerable part of the town, a bulwark system was constructed, referred to as the Krans (Eng.- " Wreath "). This surrounded almost the whole of the Town Island, and was constructed of double wooden piles joined by tie beams of timber. Entrances, fitted with booms, were provided in this bulwark system, at the towers and at the accesses to the harbours, reminiscent of the works protecting the " Vieux Port " of old Marseilles. Ships were allowed to pass these points on payment of a " pålpenning " (Eng.- " pile toll "), to guards who kept the key of the booms.

The year 1670 saw the first reference to the Skeppsbro harbour (Eng.- " Ships bridge "). This comprised the former Fiskestrand and Koggabro harbours, and was the forerunner of the present-day Skeppsbro harbour, which arrived at its present condition after a series of reconstructions. During the 19th century, the remainder of the shore round the Town Island was provided with quays.

(B). The Stadsgård Harbour.

Another part of the city of Stockholm has been used as a harbour from the earliest times. This is the Södermalm shore, in the southern part of the city, which became populated when the Town Island proved to be overcrowded. Some 300 years after the construction of the harbour at Fiskestrand, numerous jetties and breakwaters were erected on the rocky shore of Södermalm, both on the

The Port of Stockholm—continued



Mälar and Baltic sides. Reference was first made to a harbour there in 1594, and it was located mainly on the Baltic side, the structural arrangements being similar to those used at Fiskestrand.

During the 17th century, primitive wooden warehouses were erected along this harbour, and in front of these, narrow quays were constructed with substantial fenders. These installations were enlarged, and the water deepened, during the succeeding century, although the general arrangement of the harbour remained unchanged until 1875. In that year radical changes were made. The wooden structures were replaced by masonry, and a large modern quay, 570-ft. long was constructed. This entailed the removal, by blasting, of about 270,000 cubic yards of rock, and gave a quay with a width of 80-ft. Further work, lasting until 1882, produced a quay having an overall length of 1,740-ft. After an interval of 15 years construction was resumed for the third time, and a quay with a length of 7,600-ft. was obtained, entailing the blasting of a further million cubic yards of rock. Completion of the work was celebrated in 1910.

(C). Other Harbours.

In Europe the 19th century was a period of activity and progress in harbour construction. This period began in London with the opening of the East and West India Docks, and concluded with the inauguration of the Tilbury Dock. In Marseilles the construction of a series of large harbours was undertaken, commencing with the Bassin de la Joliette and finishing with the Bassin de la Pinède. At Le Harve, the Bassin de l'Eure and the Bassin de Bellot were constructed at this time.

At Stockholm the second half of the 19th century also ushered in a golden age of harbour building, and construction of permanent quays in the modern style was commenced. The old-fashioned Skeppsbro harbour was unable to handle the increasing amount of traffic, and had expanded to the shore of the nearby Nybro Bay in the beginning of the 18th century, when Nybro Quay was constructed. Later, even this expansion proved inadequate, and in 1876, Blasieholm quay was brought into use. To the north-east, the southern part of the Värta Harbour was constructed in 1879-1886, the northern section being completed in 1906-1915. Construction of the Free Port was started in 1917, and the piers of the Oil Harbour were constructed in 1927-1932. The Baltic was connected with Lake Mälar by the construction of the Hammarby Canal and a lock, in 1917-1930. At the same time a number of quays were built along both shores of Lake Mälar, and on the islands, as well as along the Hammarby Canal and its extension in Årsta Bay. Others were deepened and reconstructed to take larger loads.

The eastward extension of the Stadsgård Harbour, the Mast Harbour was constructed in 1944-1950, giving a total length of 1,650-ft., and this section of the southern shore achieved its final form.

Ground Conditions.

In general, bedrock in Sweden is of eruptive kind and was originated in the archaic period. In Stockholm and its surroundings the bedrock is almost entirely Pre-Cambrian granite or gneiss. The latter either arose from the granite by crystalline metamorphosis or was transformed of the coagulating magma by giving off its warmth. Generally, granite predominates to the North of the Lake Mälar, whilst to the South gneiss is more common.

As a rule, a variable thickness of till (in Swedish "pinnmo")—i.e. the glacial drift consisting of an unassorted mixture of gravel, sand and sometimes boulders cemented together by clayey material—overlies the bedrock. The moraine was originated by the movement of the glaciers in the end of the Great Ice Age when the melting ice masses proceeded northward and during their recession, grinded the rock surface. This material is very strong, owing to the great sheet of ice (one—two miles thick) which once covered it. It can be penetrated only by piles provided with special shoes;

The Port of Stockholm—continued

often it has to be blasted. In Stockholm these deposits are thin, mostly 1-ft.—2-ft. thick; sometimes they are absent.

Then there are the glaciofluvial deposits; stratified sediments laid down by rivers and lakes formed by the melt-waters of the glacial recession. These include the eskers and the varved clays. Fig. 3 shows quaternary deposits and reclaimed areas of Stockholm. It will be seen that almost the whole of the old town island consists of esker. The founders of Stockholm wisely established the town on this firm gravel ridge.

Foundation Problems.

The subsoil conditions are of utmost importance for the construction of quays, docks and piers as well as roads and depôts along the water front. When a hard bottom is within easy reach, foundations, in general, meet with no difficulties. In the Stockholm port area, however, the bed-rock and overlying morainic material are covered to a great extent by a layer of postglacial clay having, as a rule, an unconfined compressive strength of less than 0.4 tons/sq. ft. The thickness of this soft clayey layer is variable. It amounts, for instance, in the inner part of Stadsgård Harbour up to about 20-ft., in the Free Port up to 50-ft., and in the Gas Works Harbour up to 65-ft. These conditions were not critical in earlier times when light wooden quays intended for carrying small loads were erected in shallow waters. The crane traffic and heavy surcharges as well as the weight of robust superstructures of modern quays designed for vessels of deep draught necessitate, however, careful consideration of the ground conditions.

In those parts of the port where soft clay is found there were used several methods of improving the ground condition. In the event of a comparatively thin clayey layer (e.g. 6-ft.—10-ft.) it was often feasible to tip rock or gravel fill which displaces the underlying soft material and thus forces its way down to solid ground. If this method was not practicable there was another possibility, i.e. dredging out the unsuitable soil and replacing it with granular material. If excavating a limited furrow, experience indicated that even the softest clays held a temporary slope 2 : 1, due to the arching effect that increased the sliding resistance.

In case of great depths of soft clay it was advisable to blast, possibly in connection with partial dredging. After the granular fill has been tipped above the clayey stratum a sufficient number of pipes, 2-in.—3-in. diameter, are driven through the new fill into the clay. The charges put into these pipes are variable and depend mainly on the depth. They range usually between 10 lb. —50 lb. The distance between the pipes is usually 20-ft.—40-ft. As a result of the explosions the shear strength of the clay decreases substantially or becomes totally destroyed, hence the granular fill sinks and displaces the clay. In the Free Port the dynamite and gravel fill used amounted to 3 lbs. and 450 cu. yards respectively per linear foot of quay (Fig. 4). These figures clearly demonstrate the expense of difficult subsoil conditions.

There is also another difficulty when designing the substructure of modern quays. Previous generations at Stockholm did not concern themselves very much with the future development of the port. When constructing highways, tunnels or bridge approaches and blasting rock they often just dumped the spoil into the nearest

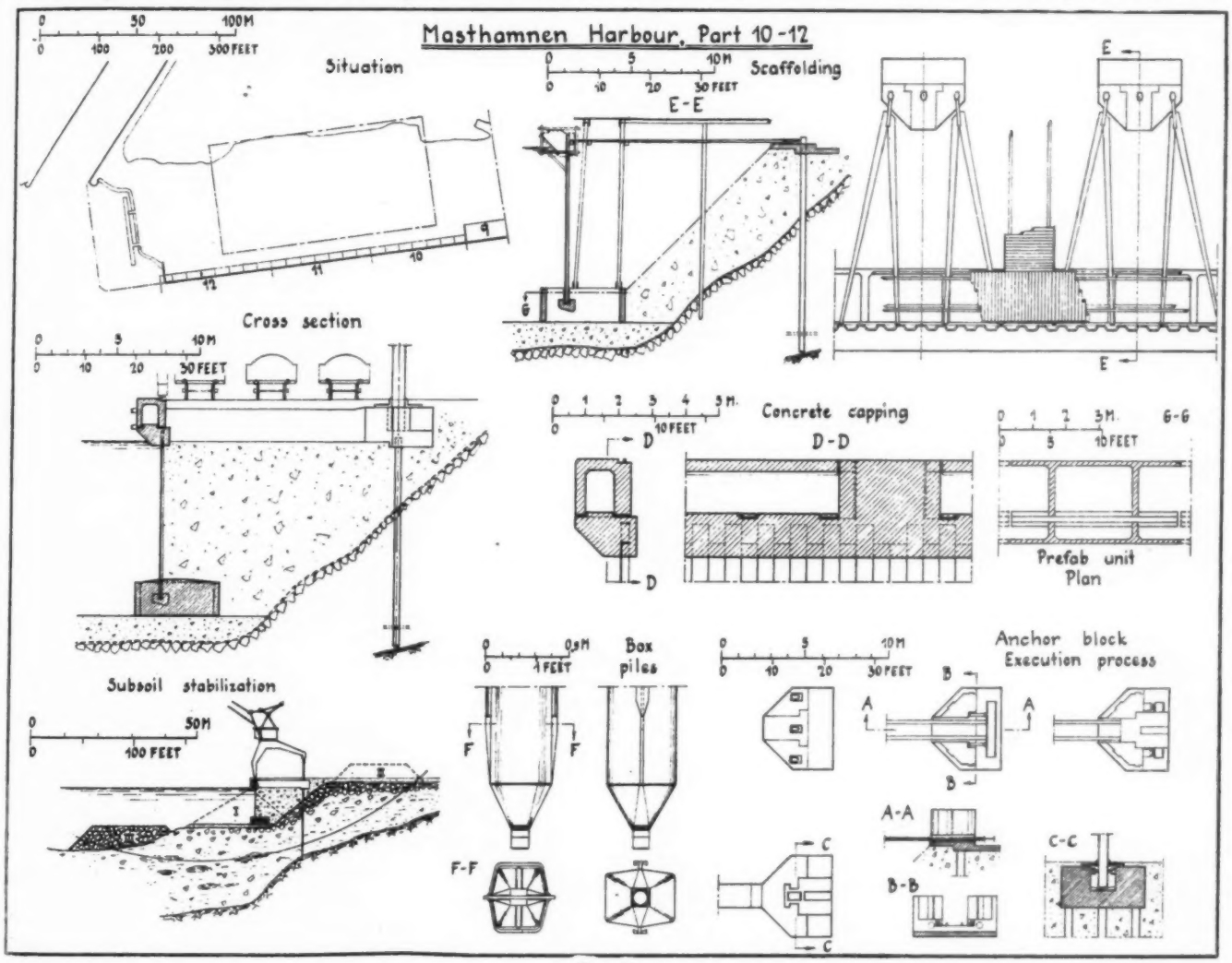


Fig. 11.

The Port of Stockholm—continued

water. Tests have shown that at many places beneath these rock dumps, whose thickness sometimes amounts to 100-ft., the soft postglacial clay remained underneath in various thicknesses and caused continuing settlement of the rock fill above. In these cases penetration of the rock fill by sheet piling has to be ruled out and even the removal of the clay by blasting is not likely to be successful because of the large thickness of the rock fill. It is thus necessary to carry the load of the quay superstructure on long steel piles driven through the rock fill to the bed-rock. About 900-ft. of Mast Harbour quay was successfully constructed in this way and numerous other designs have followed the same principle (see author's paper in the Bulletin No. 36 of Navigation Congresses, Bruxelles) (Fig. 12).

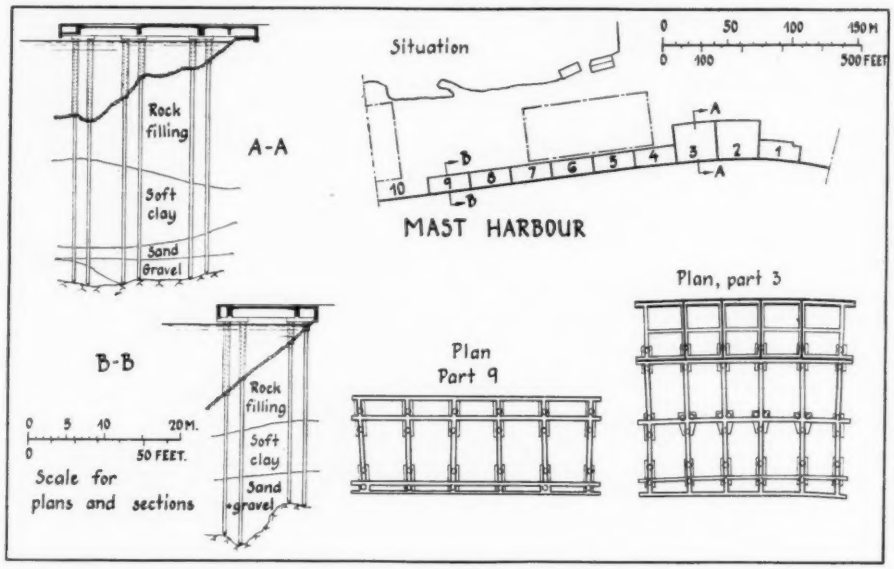


Fig. 12.

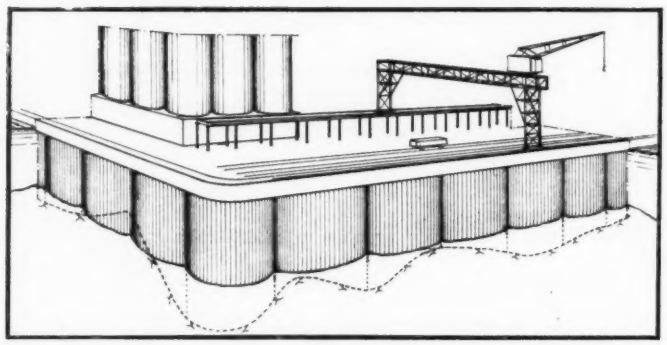


Fig. 13.

Development of Wharf Construction.

The earliest structures consisted of wooden jetties running parallel to the shore and provided the most primitive type of the platform quay. Gradually, their width was enlarged and, accordingly, the number of supporting piles was increased. Later on, land emergence has caused the water along the jetties to become shallower, and consequently, the harbour structures have had to extend towards the receding sea. Meanwhile the older structures were gradually covered by pavements and were transformed into streets and squares. Then, another century passed and improvement of the structures became necessary. The new vessels with greater draught required increased water depths, larger quay areas and greater quay carrying capacity to handle the heavier and more varied cargoes. As a consequence hereof, the planking of the superstructure was reinforced and the number of piles augmented. Finally, the piles became placed quite close together. It was then only a short step, nevertheless a decisive one, for one row of round piles to be replaced with timbered (and later sawn) ones which were provided with tongues and groves to form sheet piling walls. These were held by wooden tie-rods to groups of anchor-piles. In this way the general problem of retaining walls was solved. This occurred at the end of the 17th century. Later on, the sheeting often comprised two layers, a vertical one and a horizontal one. Almost simultaneously, however, the retaining wall construction was being evolved in another way. Wooden boxes were formed by notching together round or timbered logs with the axe and fastening them with screw-bolts. Thus cribwork came into being. It was filled with stone of which there was great abundance. Fig. 5 shows a crib placed off the old pier structure. Later, the crib was surmounted by stone masonry placed upon a solid timber flooring. The wooden skeleton of the cribwork was usually placed on the bottom. If this was not hard enough the cribs were strengthened by vertical and batter piles to transmit the load and increase the resistance to horizontal forces (Fig. 7).

In the beginning of the present century, cribs and wooden sheet piling walls combined with narrow piled platforms predominated. However, quarried stone walls often combined with cribs, where the solid granite of Södermalm was within easy reach, were also built (Fig. 6). Besides, the wooden quays were gradually reconstructed by overlaying the tops of timber piles by a wooden planking; often two layers of 3-in. to 4-in. sheeting were used. The introduction of concrete, during the last decades of the 19th century, entailed gradual replacement of wooden and stone masonry structures. Until the 1930's, however. granite facing was retained, since the quality of concrete, in earlier time, did not provide sufficient resistance against the attack of sea water and the impact of ice (Fig. 7).

A new development of quay structures was initiated when, in 1921, the Larssen sheet piling was introduced in Sweden enabling the construction of retaining walls with considerable water depths. Gradually, this type of structure proved to be the most economical.

Simultaneously, reconstruction of quays was going on in order to provide increased water depths and greater surcharges as well as to improve decayed wooden structures (Fig. 8). Everywhere, as a rule, concrete was employed as the principal material apart from steel sheet piling. This, in turn, was ameliorated by the introduction, at the end of the 1930's, of the Z-piling with the interlocks within the flanges. This piling provided a true interaction between the individual piles since taking up shearing forces was satisfactorily solved.

However, labour was becoming more and more expensive and scarce, while the prices of timber for form work greatly increased. This, in turn, gave rise to the use of prefabricated units of reinforced concrete. Fig. 9 illustrates a structure consisting of T-shaped pre-cast R.C. units, carried out in 1937. Fig. 10 shows another type comprising semi-portal R.C. frames, placed at 16.5-ft. centres to form the main construction unit upon which concrete beams and a slab were poured. These pre-cast frames were lifted and put in place by a 60-ton. floating crane. Another rather unconventional combination of pre-cast units and a steel sheet piling wall is shown in Fig. 11, which gives the various stages of construction. The operations were succintly as follows :

(1) Subsoil explorations to investigate stability and sliding resistance.
(2) Tipping waste rock 200-ft. off the quay line to improve stability.
(3) Driving box piles to carry the anchor blocks and foundation of the elevated crane truck.
(4) Manufacture of the foundation units with a channel to receive the sheet piling and sinking the units by means of a floating crane.

The Port of Stockholm—continued

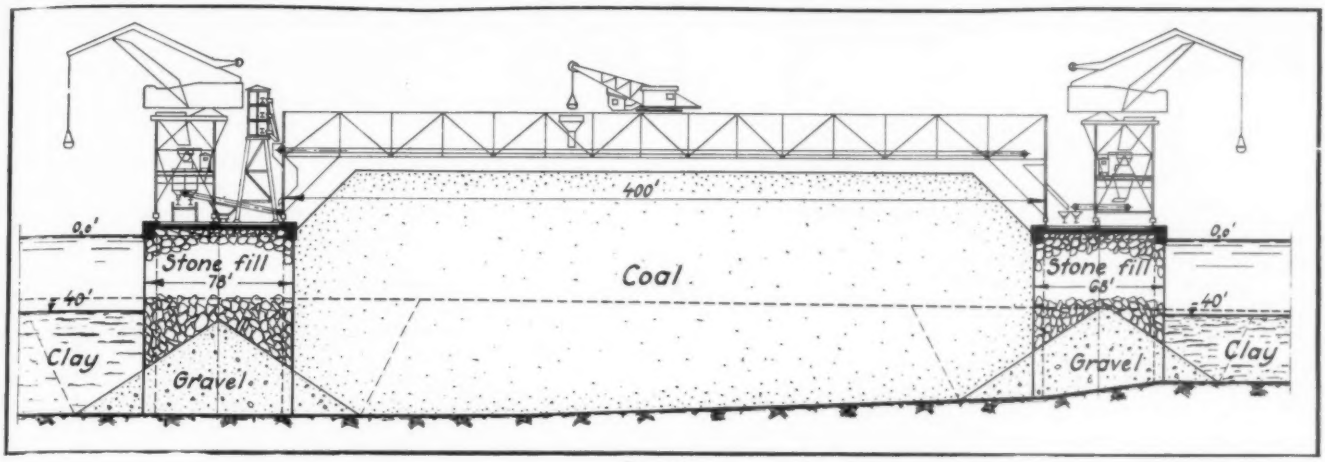


Fig. 14.

(5) Erection of scaffolding and fastening of the sheet piles which were placed into the channel.
(6) Pouring tremie concrete into the pre-cast units.
(7) Placing of the anchor bars, concreting of the lower part of the capping beams and of the anchor blocks.
(8) Pulling tests on the anchor blocks.
(9) Concreting the anchor beams.
(10) Completion of the capping beam.

The above operations and a mere comparison of Figs. 5 to 11 will indicate clearly the development that has taken place in quay structures over an appreciable number of years. (The use of prefabricated units was dealt with by the author in Bulletin No. 35 of the P.I.A.N.C.).

An example of the use of steel box piles is shown in Fig. 12. The need to penetrate 50-ft.—70-ft. of rubble fill to reach bed-rock required the driving of a large quantity of welded box piles to form the substructure of a platform quay. The superstructure consisted of an 8-in. R.C. slab carrying a live load of 650 lbs./sq. ft. and took advantage of the torsional stiffness of the heavy cross beams.

In the Free Port a steel sheet piling wall combined with large box King piles of Z-section was used to avoid future subsidence of the crane track. The track itself does not have any special pile foundation but is supported by a heavy beam carried by the box piles. To avoid bending moments in the tie-rods they were placed into boxes of concrete or, alternatively, boxes of treated pine, compensating for a 20-in. subsidence of the underlying fill. (See Bulletin 36 of the P.I.A.N.C.).

However, when designing the extension of the above quay the bed-rock, gradually, rose up to about 15-ft. below M.W.. This prevented the use of a sheet piling wall system with a fixed lower end. The variability of the rock level led to the choice of a new quay construction. Comparative investigations indicated the economy of a self-stable type that consists of building a cofferdam by means of a cellular construction filled with stone. Fig. 13 shows the general design; the first of its kind to be built in Scandinavia. It will enable a considerable reduction of under-water work to be made, besides a saving in blasting of rock.

The Stockholm Gas Works need to keep a large store of imported coal. Scarcity of storage space as well as the desirability of reducing fire risk gave rise to the general idea of the storage of coal under water. The storage plant design consists of two cellular cofferdam piers. They are to be built in lengths of 500-ft. at 460-ft. centres and carry a heavy crane for coal handling. The total coal storage will be about 400,000 tons of which about 65% are to be located under water (Fig. 14).

Warehouses and Sheds.

Protection of stored goods against the weather as well as security against theft was the primary function of warehouses and sheds. Disregarding the stores established in the houses lining mediæval Fiskestrand, the first sheds proper in the Stockholm port were the primitive wooden barns, so-called "Russian barns" erected in the 18th century in the Stadsgård Harbour and intended mainly for storing goods imported from Russia. The first sheds, constructed of stone and brick with vaulted floors, were built on the same site in the second part of the 19th century. Reinforced concrete structures were introduced as late as 1918 in the Free Port when Warehouse No. 1 was erected. It has a concrete frame with brick panel walls and mushroom floors. The upper floors of this warehouse as well as of warehouses No. II and III were provided with balconies on the quay side to enable placing goods for storing purposes (Fig. 15).

When, in 1946, warehouse No. V was enlarged by a new wing, the mushroom floors were replaced by special one-way slabs and beams supported by reinforced concrete columns. This type of floor will be also used for the proposed new warehouse (Fig. 16). The beams were very shallow to save height. On the other hand, they were extraordinarily wide (2-ft.) to give greater torsional stiffness and thus enable the fixation percentage of the slab to be considerably larger than with ordinary continuous one-way slabs. Savings up to 30% were obtained in comparison with the flat-slab

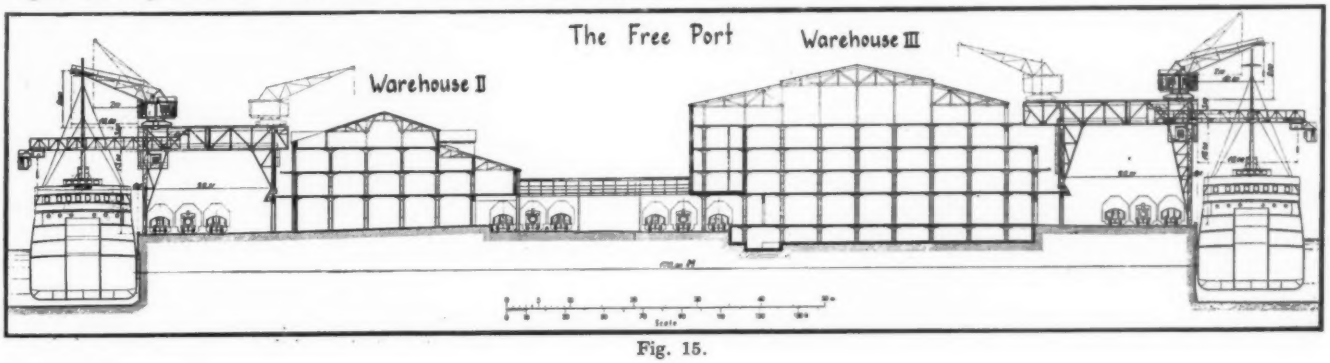


Fig. 15.

The Port of Stockholm—continued

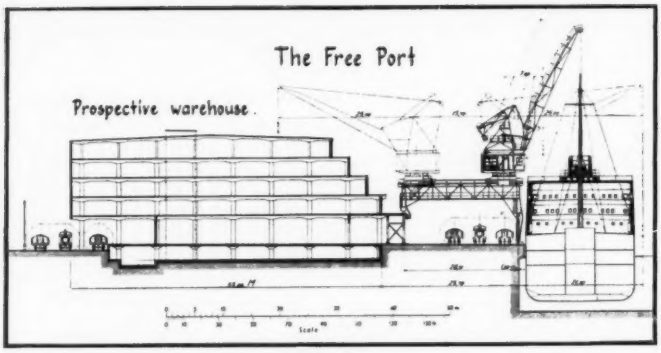


Fig. 16.

floors of mushroom type whose drops and column capitals are very expensive in form work—taking into account the rise in timber prices—whilst their two-way slabs necessitate excessive reinforcement at a time when round bars are scarce.

Another development from the wooden barns for goods not needing special storage temperatures retained the principle of single-storey buildings in timber construction. Fig. 17 shows a special shed truss, Töreboda system, of glued one-inch timber panels in shape of a triple-hinged frame structure.

Freight Handling.

The machinery generally used on wharves serves to transfer cargo between the vessel and the quay, warehouse, lorry or railway waggon and vice versa as well as traversing goods along the wharf or pier. The earliest method in the Stockholm port used the vessels' own cargo booms, masts and winches, while on the shore the cargo was man-handled by two- and four-wheeled hand trucks or horse-drawn trucks. At the end of the last century, however, hand-driven cranes and later stationary gantry or portal cranes were installed, but the travelling type was not introduced until 1897.

The great increase in the size and beam of the vessels, as well as in the weight of cargo units and, moreover, the trend of saving time and labour, led to larger and heavier cranes with more powerful engines. The wheel loads of about ten tons of 40 years ago have become quadrupled and have increased the costs of quay construction necessitating simultaneously considerable initial outlay of capital. This circumstance as well as the influence of American practice—using heavy harbour cranes only to a very small extent and relying almost entirely on the gear of vessels when loading and discharging—gradually brought about extensive employment of lighter and more flexible but less expensive units, i.e. motor trucks, fork-lift trucks, light movable cranes and tractors. At present, in Stockholm, the problem of cargo handling constitutes a good topic for discussion. Decisive steps in the choice of suitable methods might soon be taken.

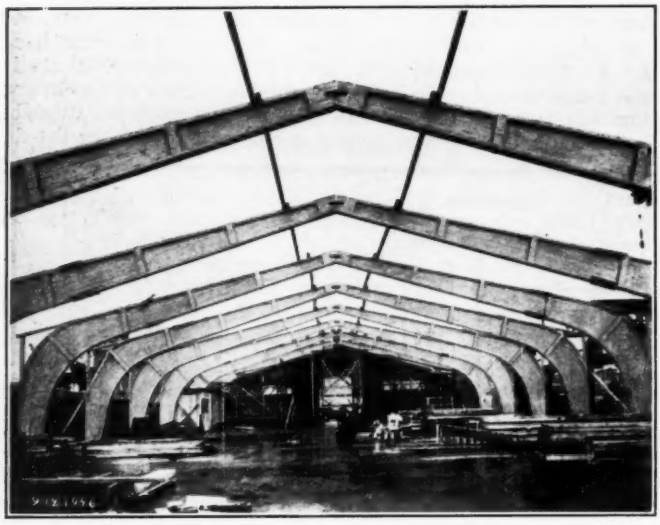


Fig. 17.

Yet, in accordance with European custom, loading and discharging in the Stockholm port is still done principally by harbour cranes. Their number amounts, at present, to 162, having lifting capacities of up to 10 tons. The above figure does not include 10 floating cranes, of which two are capable of lifting 15 and 60 gross tons respectively and the rest of lifting two to six tons. A proposal for purchasing a heavy duty pontoon crane with a capacity of 100—150 tons is to be made in the near future.

During the last two years the number of harbour cranes has been increased by installing in the Mast Harbour 12 modern electrical level luffing semi-portal cranes lifting up to five tons. Within the next few months another 14 units of most modern portal cranes lifting up to 10 tons will be delivered to the Free Port. At the same time, Northern Hammarby Harbour will be supplied with four bridge cranes for general cargo with a capacity of five tons and two gantry cranes for bulk goods lifting six tons. Besides the harbour cranes, the number of light mobile cranes, trucks and tractors will be increased in a not too distant future.

Disregarding 13 harbour cranes and four pontoon cranes — belonging to the Gas and Electricity Works as well as private firms—the entire machine equipment is handled by the Harbour Board.

The total length of crane tracks in the port area is about seven miles.

(To be continued)

Ports Efficiency Committee

Operations Panels to Speed Ship Turn-round

Port Operations Panels, consisting of representatives of port authorities, shipowners, port employers and labour, have been set up at a number of the main ports of Great Britain with the object of ensuring the most effective use of physical resources and securing the full utilisation of dock labour. Their appointment is one result of the work of the Ports Efficiency Committee, which, as announced in our April issue, was constituted last March by Lord Leathers, Secretary of State for the Co-ordination of Transport, Fuel and Power.

By meeting at frequent intervals the Panels will keep in touch with the factors leading to delays of ships or cargoes at their ports, and, where action to remove these factors cannot be taken locally, they will report the position to the Ports Efficiency Committee.

Port Operations Panels have now been established at London, Liverpool, Manchester, Sunderland, Dundee, Hull, Newport, Cardiff, Barry, Port Talbot, Swansea, Middlesbrough, The Hartlepools, Grimsby, Immingham and Leith. They can be contacted through their secretaries at the offices of the respective Port Authorities.

Parallel Committees of Port Users

A parallel set of Committees has simultaneously been set up at the ports at the instigation of the Federation of British Industries, the Association of British Chambers of Commerce, the National Union of Manufacturers, the Chamber of Shipping, and the Liverpool Steam Shipowners' Association. These Committees are known as Port Users' Committees, and function in co-operation with a central Port Users' Committee in London, and their formation has been welcomed by the Port Efficiency Committee. They serve to co-ordinate the " user " interest of shipowners and traders generally in relation to the ports at which they are set up, though their scope extends beyond the ports themselves to any delays to the movement of goods between inland points and the ports.

Generally, the function of these " user " committees is to make a survey of the berthage available, methods of cargo handling, port facilities, wagon supplies, available labour force, inland transport facilities etc.

The parts which these two sets of committees can play in improving turn-round are complementary, one approaching the problem from the point of view of the port operator and the other from that of the customer.

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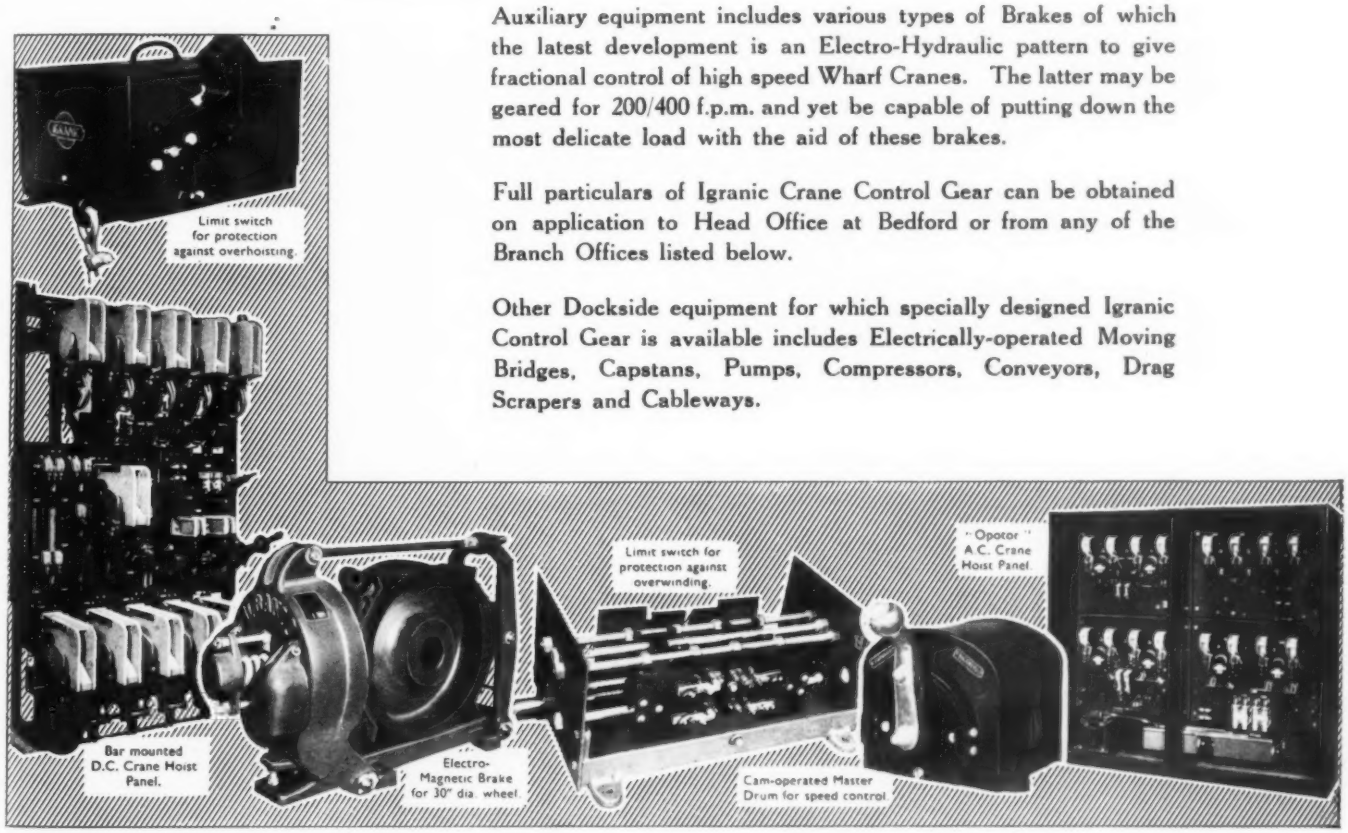
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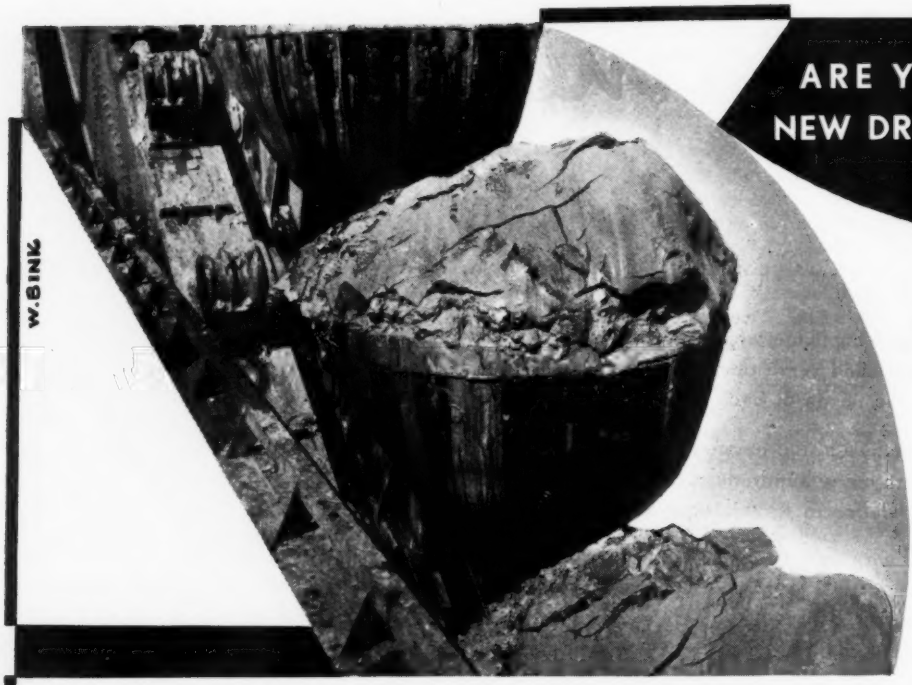

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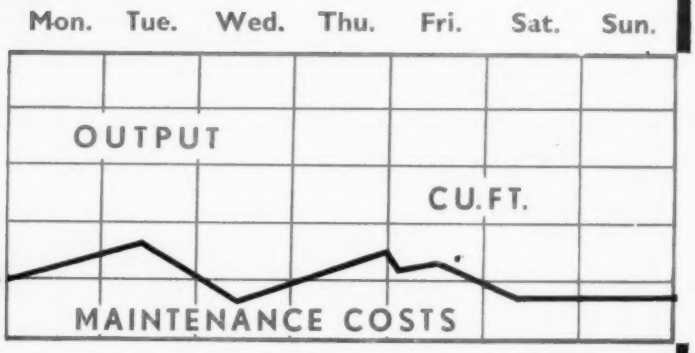

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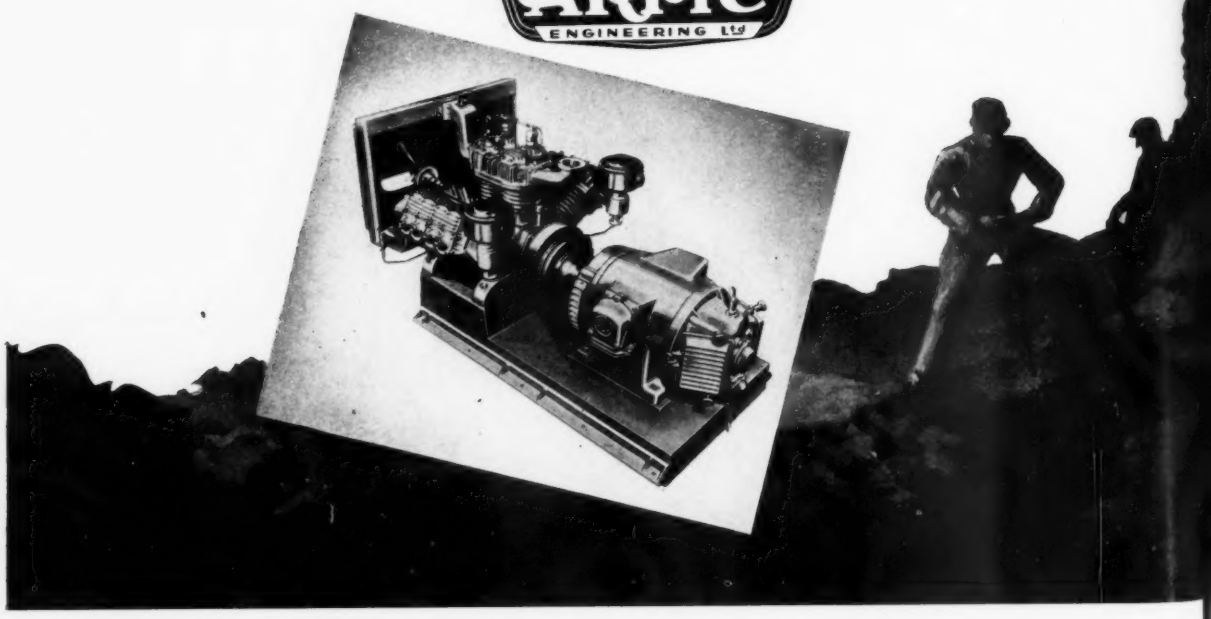

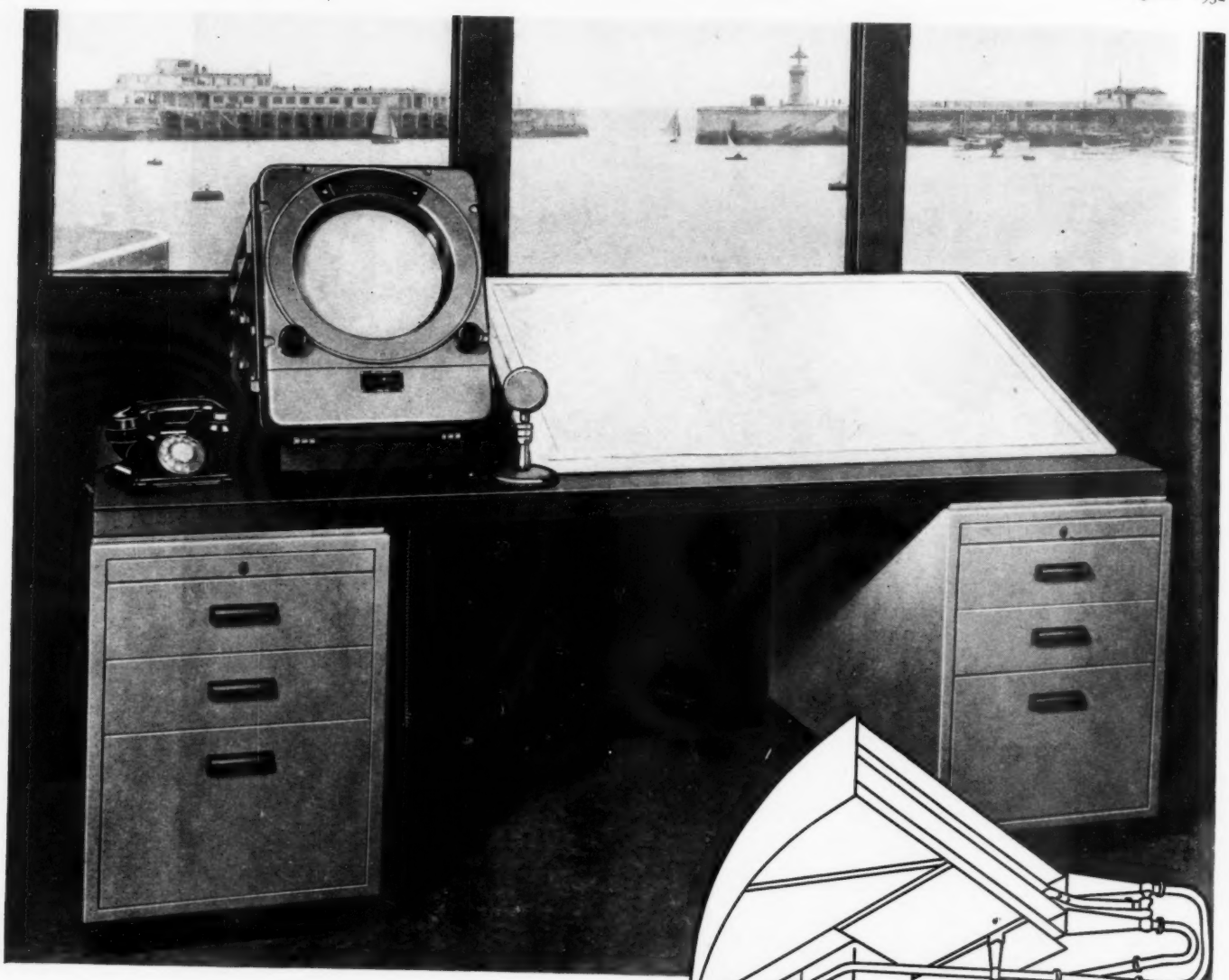

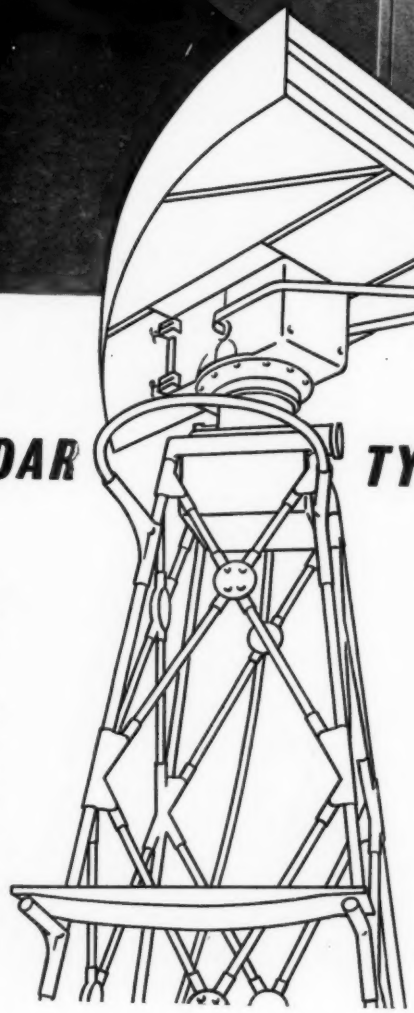

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DR 209.

Considering Dredging Craft

Recent Improvements in Design

By D. W. LOW, O.B.E., M.I.Mech.E.*

DREDGING CRAFT fall into two main types; first, the bucket dredge which mechanically excavates ground by a digging or grabbing process conducted under water and raises the material above water level for disposal, and second, the suction dredge, which raises material by suction from below water level and discharges a mixture of spoil and water through a pipe system either to a hopper or to some surface deposit site. Many suction dredges are assisted by equipment designed to break down the ground prior to its entering the suction pipe. In practice dredges are built to fairly rigid specifications, composed to meet the operator's requirements, whether he is a dredging contractor with a world-wide range, or a harbour engineer governed by the physical and economic conditions pertaining to the scheme of dredging under his authority.

The dredge is therefore a sub-aqueous excavator, a machine designed to cut the ground under water and to raise the excavated material to the surface for transmission and deposition elsewhere. Dredging craft are thus machine tools of a special type and when engaged on harbour, river or estuary works are invariably under the authority of the civil engineer in charge of these works. He may use the equipment to excavate and create new dock areas or he may deepen an existing navigable channel. In both circumstances he performs capital dredging, work essential to the creation, development, expansion and/or improvement of dock and harbour facilities. Also, the harbour engineer may use his dredging plant for maintenance duties, primarily the removal of deposits lodged by nature—and in some instances by industry — from navigable waterways in order to retain existing channel and harbour depths and widths. The massive effort and huge expenditure incurred in maintenance dredging many of the world's ports and waterways are twin features of man's incessant struggle in the interests of commerce and industry against the forces of nature.

Alluvial dredging or dredge mining is not practised in Britain at present, but substantial operations proceed in the Colonies and elsewhere overseas. This form of dredging is applied to processes whereby alluvial deposits are, in large quantities, broken down, conveyed, elevated, passed in association with water through appliances for winning metals, and redeposited on the ground. Dredge mining is usually under the charge of a mining engineer and the most common metals recovered by this means are gold and tin. Other rare and important metals and precious stones have also been recovered, but so far not in large quantity. In tin dredging, for each cubic yard of ground dredged the metal recovery after treatment may be of the order of 0.5 lb. and many areas nowadays are being dredged for values below this level. In gold dredging, for each cubic yard of ground dredged a very satisfactory standard of recovery today realizes 0.0005 lb. (3.5 grains) of bullion, and again many deposits are being worked for bullion values substantially less. These figures indicate how great is the importance of efficient treatment plant and how pressing is the urge for still greater dredge yardages.

*Paper read before the Institution of Engineers and Shipbuilders in Scotland, in Glasgow, March, 1952. Reproduced by permission.

Bucket Dredges

There are three groups of bucket dredges, each of which is sub-divided into well-established types, namely:

Multi-Bucket	Sea-going hopper dredge River and harbour dredge Alluvial dredge
Grab-Bucket	Sea-going hopper dredge River and harbour dredge
Dipper	River and harbour dredge Rock dredge

The Multi-Bucket Dredge

This is the oldest and probably most familiar type of dredge. Widely recognised as a development of this and other European countries, the type has won immense popularity in many parts of the world. Yet, in the United States of America the multi-bucket dredge has few adherents, other than in the dredge mining fields where it retains a firm grip. It has comparatively low power requirements, does not require large quantities of water to carry the spoil as in the suction dredge, and is capable of dredging to great depths. The dependability of the multi-bucket dredge is unchallenged, and the ability to dig ground ranging from easy silts and muds to hard clays and certain soft rocks, and to excavate blasted or broken rock, renders it an excellent general purpose craft in the hands of the dredging contractor or harbour engineer. The following remarks concerning the multi-bucket dredge in dock and harbour service are not entirely applicable to the alluvial dredge.

The digging equipment of the multi-bucket dredge includes the open-connected bucket chain in which each bucket is separated from adjacent buckets by links, the bucket ladder upon which rollers are fitted to facilitate the passage of the buckets on the upper side of the ladder, the lower tumbler, located at the bottom end of the bucket ladder, and the upper tumbler which is fitted on the dredge superstructure near the top end of the bucket ladder. The upper tumbler rotates to drive the endless chain of buckets carried by the bucket ladder. The lower tumbler is an idler and as the buckets move round it they cut into the dredging face, are filled, and are then elevated on the sloping bucket ladder to the upper tumbler. As they travel around this tumbler the buckets empty their contents into a drop chute from which the spoil is passed for disposal. The cycle of the bucket chain is completed by the continued downward passage of the empty and inverted buckets on the underside of the ladder, and when the lower tumbler is reached filling of the buckets again takes place.

For mooring purposes multi-bucket dredges are usually equipped with six anchors to which are attached substantial lengths of chain or wire rope. The head and stern anchors locate the dredge in the fore-and-aft direction, the head anchor taking the digging pull of the dredge, which "steps ahead" into the next dredging cut by shortening the headline. The sternline is usually kept slack but under adverse tidal or weather conditions serves to hold the dredge from being forced too heavily into the dredging face. Transverse movement of the dredge is effected through two forward and two aft sidelines and anchors suitably positioned. In traversing the dredge from side to side across the dredging face the main pulls are exerted through the forward sidelines while the aft sidelines act virtually as followers. All mooring lines are connected to manœuvring winches on the dredge, the number of these winches ranging from one in the simplest to six in the more elaborate arrangements. Assuming the bucket chain to be in operation, the dredgemaster sets the dredge longitudinally by adjustment of the headline and connecting winch, controls the dredging depth through the ladder winch, and traverses from side to side across the dredging face by movement of the sideline winches. Having completed a cut the adjustment may be one of increased depth or of advance on the headline.

In the multi-bucket dredge all dredged spoil must be raised to a high level for distribution and disposal. In vessels without hoppers, barge loading overside is the most common method of spoil disposal; less popular but very effective where practicable, is the pumping of the spoil to a reclamation area. Long overboard chutes were at one period used with good effect, but the modern equivalent is to carry the material on conveyors and stack it on shore at a distance well beyond the range practicable for long chutes.

The Sea-going Multi-Bucket Hopper Dredge. This type was in great demand

Dredging Craft—continued

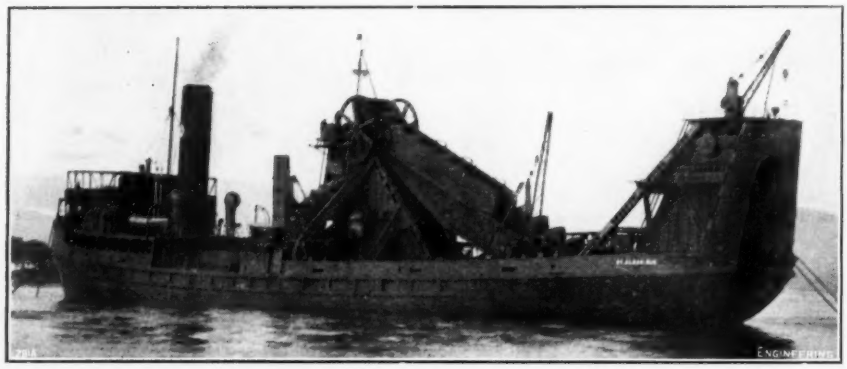


Fig. 1. Stern-Well Multi-Bucket Dredge *St. David* (Ex *St. Alban*).

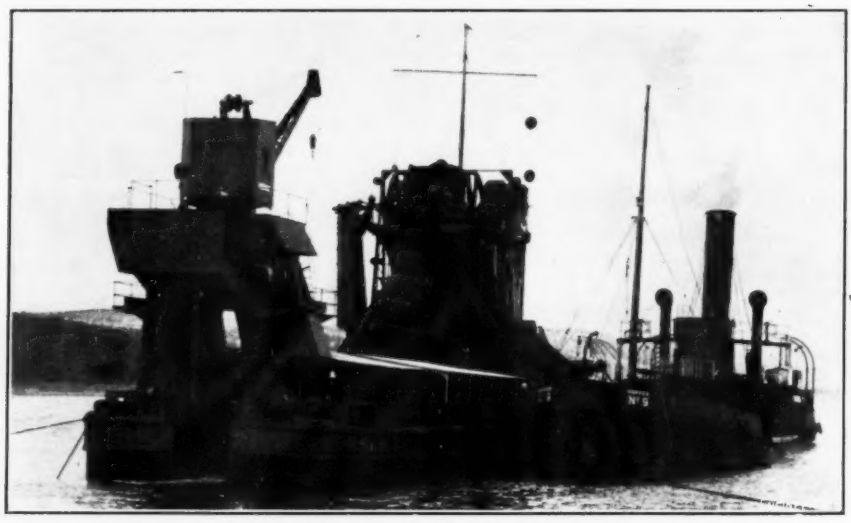


Fig. 2. Non-Propelling Multi-Bucket Dredge *A. D. Mackenzie*.

and has made a major contribution to port development. Arranged with a central hopper and bottom opening doors, after the hopper is filled it slips and buoys the dredging moorings and proceeds to sea to empty the hopper. On returning, the moorings are connected and dredging is resumed. Where one dredge is required to service several ports this type still has a useful function as it can perform these duties unaided by other craft. Dredging carried out in this manner is, however, costly, as the ratio of dredging time to total hours worked is low, so much of the working time being absorbed in handling moorings and steaming a relatively large craft to sea to perform the work of a hopper barge. The design, in addition to self-loading chutes, usually includes provision for discharging overboard on both sides. With an appreciable volume to be dredged it is advantageous to station the vessel for dredging only and use hopper barges for the carriage of spoil.

It may be designed either with a stern well or bow well. For sea-going qualities and where long sea passages are likely to be frequent the stern-well craft is superior, but the ladder well aft necessitates the installation of twin-screw propelling machinery and, to secure a balanced design in a steamer, the placing of the boilers forward of the hopper, so that the main framing may be accommodated between the fore end of the ladder well and the after end of the hopper. Fig. 1 illustrates a dredge, completed in 1940, which has accomplished great work in many ports of the world under conditions of peace and war. The principal particulars are:

Length B.P., ft.	265
Breadth, moulded, ft.	47·5
Depth, moulded, ft.	18
Hopper capacity, cu. yd.	1,000
Normal dredging depth below waterline, ft.	60
Maximum dredging depth below waterline, ft.	75
Bucket capacity, cu. ft.	28
Rated output, cu. yd., per hr. ...	700
Loaded service speed, knots ...	10

The ladder gantry at the after end is a massive structure, unusually high to meet the requirement that, with the ladder housed, the catenary of the bucket chain must be clear of the water when propelling. The gantry carries the suspension gear for the bucket ladder and the driving mechanism by which the ladder is raised and lowered, and forms a strong tie to bind those sections of the hull which, running from the main framing to the stern, create the ladder well. The upper tumbler is driven by shafting and gearing and 700 i.h.p. is available for dredging duty. The dredge is equipped for rock dredging with a second bucket chain, each bucket having a capacity of 14 cu. ft., which is interspersed with ripping claws. The specified definition of rock was "the hardest material which can be dredged in normal bucket dredge practice without previous blasting." In service the dredge has far exceeded this definition and, in one instance, gave very satisfactory results when dredging elvan and shillet in the natural state.

The River and Harbour Multi-Bucket Dredge. Dredges of this type are not equipped with a hopper and are designed in three forms, non-propelling, bow-well self-propelled, and stern-well self-propelled. The non-propelling form requires the lowest capital outlay and is a popular and very useful dredge, arranged to discharge the dredged material into hopper barges moored alongside. An additional feature of pronounced value that can be introduced is a sand pump for the disposal of spoil through a pipeline. The bucket contents are emptied into a central sump, into which water is admitted; the sand pump draws from this sump and discharges the mixture of spoil and water through a floating and shore pipeline to a reclamation area. Before reaching the sump the spoil is passed through a disintegrating medium in order to reduce the possibility of choking in the sump. Where practicable, this method of disposal is more efficient and economical than the use of attendant hopper barges; there is a saving in manpower and fuel, and land may be reclaimed for future development. In the non-propelling dredge a transverse dredging engine can be arranged to drive the upper tumbler through belts and gearing, an efficient arrangement giving entire satisfaction under the most onerous dredging conditions.

The multi-bucket dredge illustrated in Fig. 2 was completed in 1951 and is the fifth of this size and type built by the Author's firm since 1946. The salient particulars are:

Length B.P., ft.	178
Breadth, moulded, ft.	36
Depth, moulded (mean at midships), ft.	12.5
Normal dredging depth below waterline, ft.	46
Maximum dredging depth below waterline, ft.	60
Bucket capacity, cu. ft.	28
Rated output, cu. yd. per hr. ...	700

The hull has a droop of keel which allows for the loss of buoyancy due to the ladder well and for the substantial difference in weight which exists with the heavy digging equipment forward and the relatively light boiler and engine room components aft. The ocean voyage condition under tow with the bucket chain dismantled and stowed on deck and in the holds is an important limiting factor in the design. A range of stability of about 45° is acceptable to the Ministry of Transport for ocean passages and, having attained this condition, it is usually found

Dredging Craft—continued

that ample stability exists for the dredging condition, in which there is a fair change of trim between the extreme positions of the bucket ladder—up and on the bottom.

The machinery is steam-driven. A triple-expansion, enclosed, pressure-lubricated engine is placed transversely in the engine room and drives the upper gearing and tumbler through two belts. For normal dredging conditions the bucket speed is 18 per min. and should it be desired to carry out arduous dredging in very hard ground an alternative bucket speed of 14 per min. is available. Both the upper and lower tumblers are annealed steel castings with integral shafts, and the faces upon which the buckets ride are hard-surfaced with weld deposit. This design of upper tumbler has disposed of the old problem of key slackening common in two-piece tumblers. The lower tumbler revolves in bearings specially designed to exclude sand and other foreign matter, and this arrangement has displaced the fixed shaft design so long established. All rollers on the bucket ladder and the lower tumbler are coupled to an elaborate lubrication system which is automatically controlled.

The buckets are one-piece steel castings with hard-surfacing deposits applied to the cutting edge, maintained by welding rod only. Their superiority over the outmoded composite and riveted bucket has been well proved in service. The design of the bucket is simplified by having single eyes for the bucket pins. Adjacent buckets are thus connected together by four links instead of two, which is a distinct advantage in the maintenance handling of the bucket chain. Freely rotating manganese steel bucket pins close the chain.

The bucket ladder is entirely welded; the top suspension eyes and the bottom tumbler bearings are neatly welded into the steelwork and displace the steel castings which, in previous designs, were riveted at these points. Fitted at the top of the ladder is an auxiliary ladder which, at shallow dredging depths, improves the running conditions for the buckets as they approach the upper tumbler, while at dredging depths between 46-ft. and the maximum at 60-ft. it is the support for the upper end of the bucket chain. The top end of the ladder and the framing are designed to permit the ladder to slide down and up without interference with the auxiliary ladder.

For manœuvring purposes the dredge is equipped with one headline winch, two forward sideline winches and one winch aft which handles the stern anchor and two aft side anchors. The bucket ladder is suspended by wire ropes from a barrel mounted in the ladder gantry, which also accommodates the ladder winch. The dredgemaster's operating position is forward on the port side and from this point he operates the headline winch by remote control, is in close proximity to the forward sideline winches and their winchmen, the controls for the ladder winch and the dredging depth indicator, and, on two telegraphs, signals respectively to the engine room and to the after winch. Finally, an emergency control is arranged so that the dredgemaster may stop the dredging engine instantly. In practice this control is frequently used for routine stoppages and the engineer on watch merely resets a trip mechanism so that the engine is ready to be started on command.

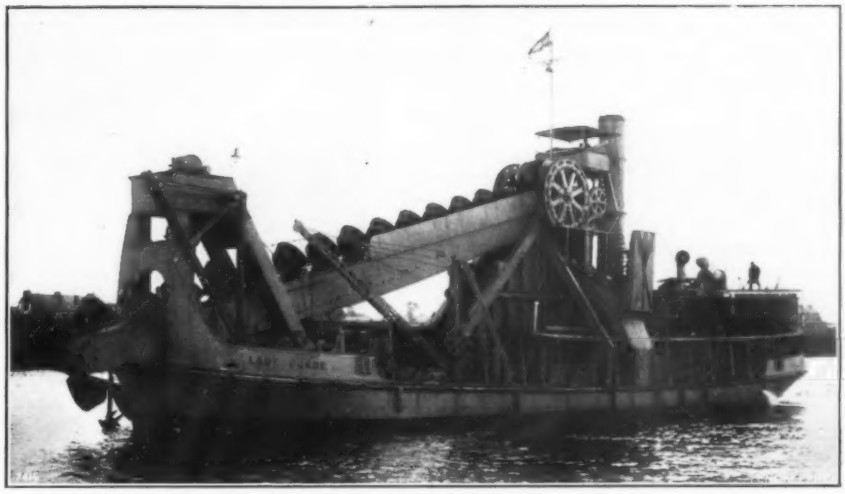


Fig. 3. Bow-Well Multi-Bucket Dredge *Lady Combe*.

Fig. 4. Stern-Well Multi-Bucket Dredge *Belomorskaya*.

A typical bow-well self-propelled multi-bucket dredge is shown in Fig. 3. This type is not primarily intended for ocean passages but is equipped with propulsion equipment to facilitate movement between dredging areas within closed or coastal waters and is usually fitted with a single engine which, with an arrangement of clutches, drives either the propeller or the dredging gear. In most instances the drive to the upper gearing and tumbler is by shafting, a system now considered outmoded. Opinions on the merits of shaft drives and belt drives are sharply divided but the Author is a staunch supporter of the belt drive. It will be observed that the bow-well type produces a balanced ship arrangement, with the engine and boiler rooms aft, the main framing roughly amidships, and the ladder well forward. Many dredges of this type have given satisfactory service but some criticism can be offered. Generally, the installed power is low, hence the speed is low and manœuvrability weak. This feature is accentuated by a full hull form, while the inclusion of statutory Ministry of Transport requirements for self-propelled vessels adds nothing to the dredging efficiency and this, in the final issue, is the feature that matters most. Bow-well dredges can be arranged to have an adequate ladder overhang for bank dredging ahead.

The stern-well self-propelled multi-bucket dredge illustrated in Fig. 4 was designed for service in Arctic Russia. This dredge first operated in Murmansk and later served in a number of White Sea ports. The ability to move freely between ports was essential and, as weather conditions there are frequently bad, the dredge had to be very seaworthy. In certain ports barge loading was not used and the arrangements for spoil disposal included two sand pumps capable of series working to discharge the spoil ashore through long pipelines. The machinery installation included one central engine, directly connected to a shaft drive for upper gearing and tumbler, and two wing engines, arranged with clutches for driving either the propeller shafting or the sand pumps. This class of dredge is used for bank dredging in capital works but there is always a danger that the propellers may be damaged when breaking down the dredging face.

The Alluvial Dredge. Alluvial or mining dredges are invariably multi-bucket dredges with close-connected bucket chains, in which

Dredging Craft—continued

each bucket is directly connected to the adjacent buckets, without the intervention of links as in harbour dredging practice. The close-connected bucket chain is capable of a much higher throughput, causes less surge when digging at the lower tumbler, has a much greater weight and, in general, produces a more uniform and effective dredging load. There are several obstacles to the use of this chain for harbour work, and of the more important, cost and an unbending outlook to changes rank high. Nevertheless, harbours and rivers frequently produce a motley collection of old anchors, chains and other weighty or voluminous oddments; these and boulders or loose rock of large dimension might not be friendly to a close-connected bucket chain. Standard practice for dredge mining is to use manganese steel buckets having three connecting eyes and renewable, rivetless, manganese steel lips. Some recent bucket designs have eliminated such lips in favour of weld deposition as wear takes place.

Amongst many dredges operating in mining fields overseas are a few capable of digging to a depth of around 130-ft. below water level. These deep-digging dredges have reached mammoth dimensions and capacity, and correspondingly high capital costs. So serious has this feature become that, in an effort to reduce the outlay, experiments are being made to dredge to deep depths with grab buckets, but some time must yet elapse before convincing results are obtained. Several attempts have been made to apply suction dredges to mining but so far none is known to have been successful.

In dredge mining, as in harbour practice, the capacity of the bucket is an important indication of dredge size and output. To the Author's knowledge the largest bucket capacity yet used in a close-connected chain is 20 cu. ft. and the largest in an open-connected chain 54 cu. ft. The former is a modern size while the latter has not been repeated for many years. The normal maximum bucket size used in current harbour practice is around 30 cu. ft., although consideration was recently given to a 54 cu. ft. close-connected bucket chain for the excavation of blasted or broken rock in a capital dredging scheme.

The digging equipment of an alluvial dredge consists of the same components as in the harbour dredge but the design of the buckets and lower and upper tumblers differs. The lower tumbler is usually circular and the upper tumbler hexagonal with an advanced design stepping up to seven sides. For mooring purposes wire ropes are used, generally attached to solid anchorages on shore. The headline dredge operates with five lines, a long headline being run out and the dredge traversed laterally by four sidelines about the headline anchorage as a centre. The dredging face thus forms an arc of a circle with the convex side towards the dredge. The spud dredge is an alternative which uses four sidelines and has one or two spuds fitted at the after end. In operation, it swivels about one spud and is traversed across the face by the forward sidelines. The after sidelines are invariably laid out to give a forward movement to the dredge when required but, in the ordinary way, they lie slack. This method of dredging also introduces an arc into the dredging face, but of small radius and having the concave side towards the dredge. For hard digging conditions, as in cemented gravels, hard clay, boulders, etc., the spud dredge gives an excellent performance and higher throughput than the headline dredge, which is at its best in easier dredging conditions.

Modern alluvial dredges are invariably electrically operated and this feature permits easy centralization of all dredging controls in the operating house. Manœuvring winches number from one to five. The recent trend to use a number of winches has arisen mainly to keep the deck clear of spreading wires and fairleads and to secure superior operating control.

Fig. 5. Alluvial Gold Dredge *Bremang No. 3.*

In mining each dredge has three main functions: first, excavation of the metal-bearing ground; second, the washing and treatment of that material in order to recover the valuable metals; and third, the rejection of the waste overside after treatment. The dredging procedure is sometimes known as movable pond dredging. The dredge floats in a pond into which water either flows or is pumped and, as excavation takes place ahead, so the dredge moves forward, depositing as it moves the reject tailings to fill in the space already dredged out. River dredging also takes place in this sphere of mining.

When the buckets empty their contents over the upper tumbler and into the drop chute the material passes aft into a revolving screen in which high pressure water jets break it down until the small particles pass through the screen perforations, while the oversize reject travels down the screen to be conveyed astern of the dredge. After being washed and separated in the screen the fine materials are collected for distribution and treatment, either in jigs or on tables where metallic recovery is effected. In association with water the reject fine material is passed overboard on tailing chutes which deposit well astern of the dredge. The volume of concentrates recovered from jigs or tables is subjected to further treatment on board the dredge in order to reduce the non-metallic content, and to bring either the tin or the gold to a stage ready for still more processing. Tin is invariably capable of recovery in the raw state but gold is frequently recovered with the aid of mercury, the union producing an amalgam which may average a 50 : 50 mixture of gold and mercury. Fig. 5 illustrates a mining dredge at work in tropical Africa on the recovery of gold from large alluvial deposits.

To conclude these observations on dredge mining a word should perhaps be included regarding a small dredge recently despatched overseas for re-erection and now

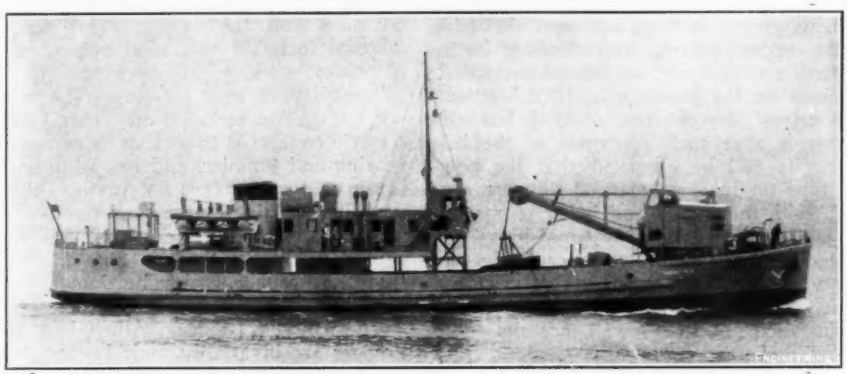


Fig. 6. Grab-Bucket Hopper Dredge *Mersey No. 14.*

Dredging Craft—continued

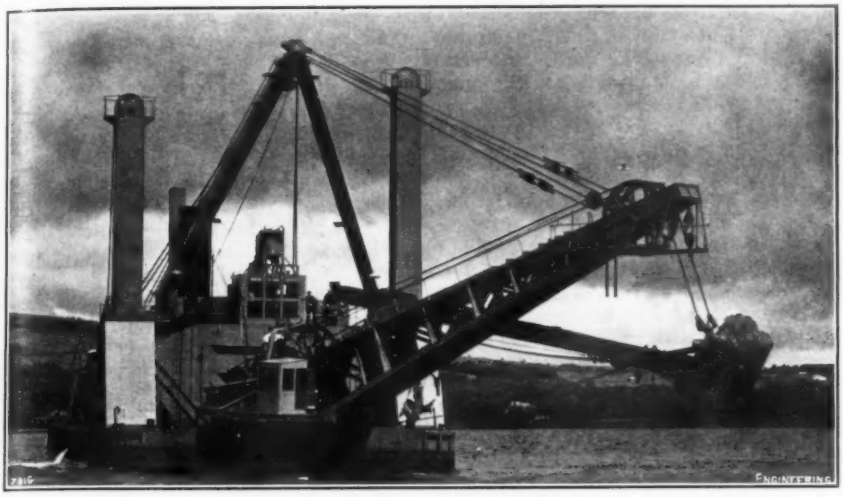


Fig. 7. Dipper Dredge *Kala Nag*.

completing extensive trials. This dredge is electrically operated by a power supply at 500 volts D.C. It was built on the shores of a trona lake in which reconstitution of the trona, a mixture of soda and salt, takes place within a few months. The dredge floats on a liquor having a specific gravity varying seasonally from 1.1 to 1.3 and digs trona from about 7-ft. below liquor surface. The trona is elevated and delivered into a three-stage crushing plant from which it emerges in condition to be pumped through a floating pipeline to the shore plant, where further treatment takes place. Dredging operations have been continuous on this lake for over 30 years.

The Grab-Bucket Dredge

These have an important place in the dredging world, being used extensively in harbour works where siltation is a problem and where " hole and corner " cleaning of dock bottoms and other waterways must be accomplished. They are particularly useful for removing silt alongside quay walls, positions to which most other dredges cannot gain access. Their ability to take up a dredging position and to withdraw speedily is a valuable attribute. Because there is no horizontal digging thrust, as a rule no headline is required and dredging is carried out on four sidelines. However, a strong current may demand a head anchor or other means of holding position. The grab dredge is well suited to perform many requirements of maintenance dredging and will give a good performance in easy dredging conditions of mud, loose sand and silt. It has a low capital cost and is economical to operate. Maintenance, too, is cheap due to the small number of wearing parts in the digging equipment. It is not, however, a suitable type for large-scale capital works, is not inherently suited to hard dredging conditions, and lacks the range of dredging capability which exists either in the multi-bucket or in the dipper dredge.

The Sea-going Grab-Bucket Hopper Dredge. The self-propelled hopper dredge, fitted with one or more grab cranes, has proved an eminently practicable type within the limits described. Except probably in the single-grab dredge, the size and number of grabs should be dictated by two features, the dredging cycle and the deposit cycle. The former includes the time to take up and let go moorings and the time to fill the hopper—which is, of course, related to the grab bucket capacity and speed of operation, and the hopper volume; the latter covers propelling time to and from deposit site and the time taken to empty the hopper. Single-grab dredges are invariably designed with limitations on their dimensions and capacity, with the intention of making them do sundry jobbing. Most single- and multiple-grab dredges are designed to operate around the bows, a most desirable feature and, in the multiple-grab types, preference appears to be for the twin- or triple-crane installation. The beam of these craft is influenced by the angle of heel created by the grabbing pull exerted when the crane—or cranes—is working at a fixed radius athwart ship, and by the rolling motion set up by the rapid cycle of digging and slewing. The digging equipment of a grab dredge is the bucket and crane. Various types of grab buckets are available for service in different conditions but the ability of the bucket to penetrate the ground as it makes contact, to gather the ground as the sides close together, and to hold the ground while being raised to the surface, are important criteria in the dredging efficiency.

The Diesel-electric, self-propelled dredge, Fig. 6, is a recent addition to the fleet of a major port authority. The main particulars are:

Length B.P., ft.	143
Breadth, moulded, ft.	32
Depth, moulded, ft.	12.75
Hopper capacity, cu. yd.	300
Maximum dredging depth below waterline, ft.	50
Bucket capacity, cu. ft.	50
Rated output, cu. yd. per hr. ...	130
Loaded service speed, knots ...	10

This dredge operates on the constant-current system with the main electric generators, propelling motors, deck machinery and hoisting and slewing motors for the grab crane connected in a series loop. The current is kept at a constant level by a special motor-driven exciter set, and this system automatically prevents any overloading of the Diesel engines, generators or motors, however rapidly the controls are operated. Voltage to earth at any point in the system is limited to 600. The engine room auxiliaries, excitation and lighting circuits are supplied from constant-voltage generators coupled in tandem with the main generators so that all services are supplied without the necessity of running an auxiliary set.

The River and Harbour Grab-Bucket Dredge. Non-propelling dredges having a grab crane fitted to a pontoon exist in vast numbers. These craft usually load into dumb hopper barges which are towed either to a deposit site, where the hopper contents are disposed by opening the bottom doors, or to a pumping station which extracts the contents from the hopper and discharges them to a reclamation area. Manœuvring on this class of craft is frequently by hand winches and everything practicable is done to keep to bare essentials.

The Dipper Dredge

The dipper dredge has not sustained favourable interest in this country and the attributes of the type seem to have been neglected. Many dipper dredges were at

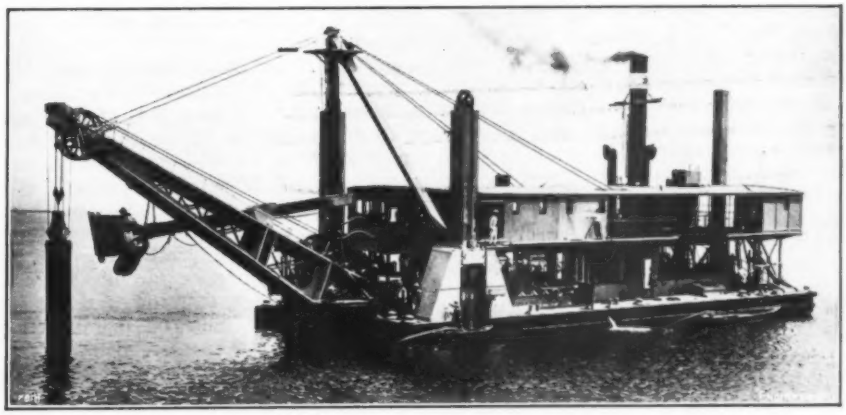


Fig. 8. Rock Dredge *Choshi*.

Dredging Craft—continued

work in Eastern countries until 1939 and were known to have given satisfactory performances under variable service conditions. In the United States the type is used only for the toughest of dredging duties and is complementary to the suction dredge. There it is recognised as an economic dredging unit of moderate capital cost and low maintenance charges. The salient features of this dredge make it more versatile and capable of dealing with harder material and a wider range of work than other types of dredge.

The steam or Diesel shovel is recognised as an efficient means of excavating earthwork; the dipper dredge is the floating steam or Diesel shovel. The single bucket, or dipper, mounted on the end of a pontoon is arranged to have universal motion within certain angular limits. In operation, the bucket and dipper arm are made to perform movements analogous to a man shovelling. The digging equipment consists of the boom, dipper arm and bucket. The boom carrying the dipper arm and bucket, is seated on a large baseplate strongly attached to the deck, and is suspended from an overhead frame so that it may revolve transversely through an angle of fully 180°. The dipper arm and bucket are rigidly mounted together, and the arm is designed to slide through a saddle-block located about the mid-length of the boom and arranged to pivot in the vertical plane. A feed motion to the bucket is operated by the arm. Wire ropes from the barrel of the main hoisting machinery pass through a system of fairleads in the hull and on the boom until they connect directly with the bucket, which is made to respond to these motions. When hoisting, the bucket describes an arc about the saddle-block as centre; when feeding, the radius of action of the bucket is varied at will and, when revolving about the vertical axis of the boom base, the bucket may be positioned to dig or deposit anywhere within the designed radius of action by operating the feed to the dipper arm.

The dipper dredge is usually anchored for dredging by three spuds, two forward and one aft, without any external moorings. It has a large degree of mobility and can be manipulated over the dredging area by skilful use of the bucket and the spuds. The entire digging and manœuvring procedure is in the care of the dredgemaster and boom attendant who work in unison. The dipper bucket works ahead, making successive cycles until the entire face or bank within range is dredged away. The dredge is then advanced, the spuds are reset, and another cut commenced. This type can dig its own flotation through a bank many feet above water level and without danger from the collapse of such a bank.

Spoil disposal is effected by loading into barges alongside or by depositing direct on the river or canal banks, provided these are within dumping range. Barge disposal is mostly used for harbour and river dredging, and deposition on the banks in waterways restricted by width. The dredged spoil is not brought on board the dredge, as must be done in most other types. Dipper dredges are generally and preferably arranged as non-propelling craft, as several features peculiar to them render the inclusion of propelling machinery something to be avoided. A very few of these dredges have, however, been equipped with propulsion equipment.

The River and Harbour Dipper Dredge. The vessel shown in Fig. 7 is a steam-operated, 11 cu. yd. dipper dredge built recently for service in France and in particular to clear the tremendous damage done to the port of Le Havre. In operation the power is concentrated through the single bucket, which exerts a tremendous digging force at the cutting face. This dredge has set an exceptional standard in its present service.

The main particulars of the dredge are :

Length B.P., ft.	130
Breadth, moulded, ft.	50
Depth, moulded, ft.	12
Maximum dredging depth below waterline, ft.	53
Outreach at boom sheaves, ft. ...	68
Maximum outreach at dump height, ft.	85.5
Dump height, ft.	18
Bucket capacity, cu. yd.	11

The boom is suspended from the overhead frame by wire ropes and this frame has, in turn, wire back stays. The boom base is retained in sockets by heavy springs, and the entire arrangement is therefore one of flexibility, with allowance for the boom to rock or roll and thus avoid excessive loads. A separate winch is installed on deck for swinging the boom and is remotely controlled from the operating house.

The dipper arm is of laminated construction, with wood filling between steel plates and sections. Again flexibility is the aim and the flitched beam design has proved successful. The winch located and operated on the boom is devoted solely to manipulating the feed of the dipper arm through the saddle-block on the boom, this movement being used on every cycle when dropping to dredging depth, when holding the bucket to the cut, and when thrusting the arm outward to dump the spoil load.

Each forward spud is about 90-ft. in length and weighs 40 tons. A two-barrel independent winch placed in the hull is connected by wire rope to each spud and is connected by wire rope to each spud and is controlled from the operating house. When the spuds are run down to touch bottom the hull assumes a condition of free flotation without the weight of the spuds. As the spud winch exerts a downward thrust on the spuds in contact with the bottom, so the hull is raised partly out of the water, and it is in this condition that dredging takes place. In this dredge the hull lift above free flotation to secure complete stability for dredging varies between 1-ft. 6-in. and 2-ft. 6-in. The utmost care must be maintained lest spud sinkage into the ground or tidal conditions create a variation in spud loading which would upset the working stability of the craft and special automatic draught gauges are fitted in the operating house so that a constant record of the amount of hull lift is evident.

The after trailing spud is also driven by an independent winch placed on deck and locally controlled. This spud is arranged to swivel in the fore-and-aft plane as the dredge moves ahead to the next cut. It acts as an anchor while the bucket makes the dredge "step ahead." Once the new dredging position is attained the forward spuds are run down, the dredge set, and the after spud raised from the trailing position to the vertical, where it exerts adequate thrust to act as a stabilizer.

The Rock Dredge. This is a combination of dipper dredge and rockbreaker. To the features of the dipper dredge is added a rock-breaking attachment, consisting of a rock-cutting chisel operated by the hoisting engine, and an underwater guide, coupled to the boom winch. Dredging and rockbreaking do not take place concurrently, as the same machinery is used for both purposes, but the transfer is accomplished very speedily. This dredge has the decided advantage that it can break rock under water and then raise it to the surface — an advantage not yet fully exploited. Where a modest volume of rock has to be excavated and large-scale expenditure cannot be warranted, the system offers both efficiency and economy of operation. A typical arrangement of the rock dredge is shown in Fig. 8.

(to be continued)

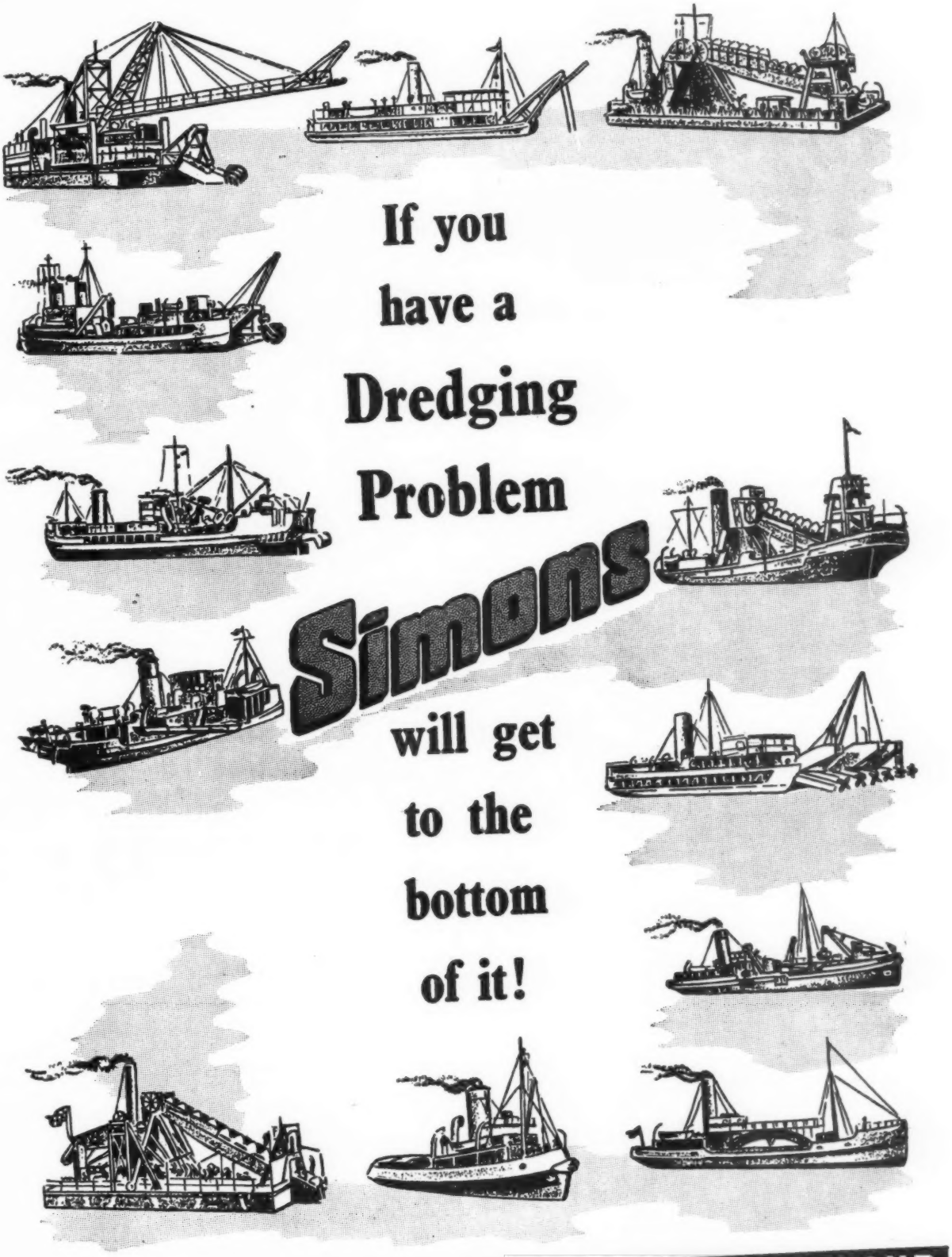
Development of Pakistan Ports

A progress report of Pakistan's Ports for the fiscal year ended March 31st last, gives the following details:

The total tonnage of imports and exports which passed through Karachi during 1951-52 was 3,719,400 tons as compared with 2,184,000 tons during 1947-48. The construction of a commercial dry dock at an estimated cost of Rs. 12 million has been sanctioned and when completed will make Pakistan self-sufficient in drydocking facilities for its mercantile marine.

To cope with the increasing traffic now being handled at Chittagong, which is due to the Port having to import capital goods and consumer goods to meet the needs of the Province and also to serve as an outlet for the bulk of the agricultural produce, immediate and long-term plans for the expansion of the Port at a total cost of about Rs. 150 million were formulated. The immediate plan has been completed and the Port with its 15 berths can deal with 2.5 million tons of cargo a year. In 1948, the port had jetty accommodation for only four ships.

The Chalna Anchorage has been developed to handle 500,000 tons of cargo per annum, thus achieving the target set for its development. It can accommodate four ships at moorings, while other ships can lie at their own anchorages. The Anchorage was opened to deep sea traffic in December, 1950, with one set of moorings, the second set being laid in March, 1951. During the period under review two additional sets were added in October, 1951 and March 1952 respectively.



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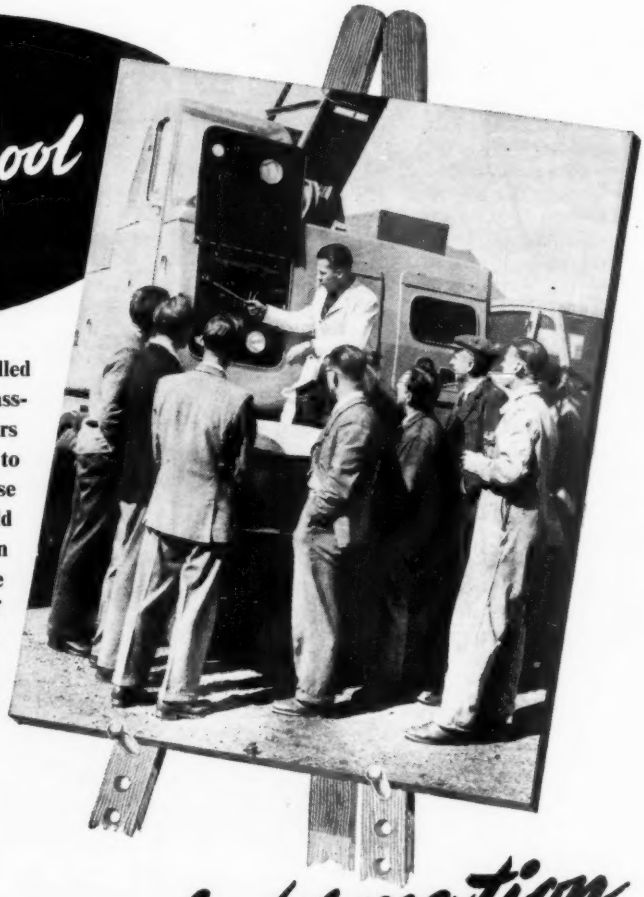

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BELTING AND HOSE

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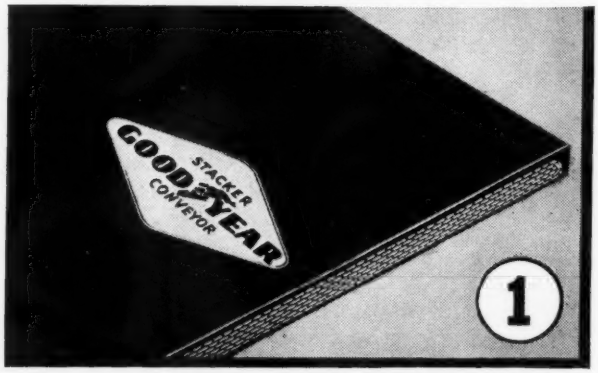

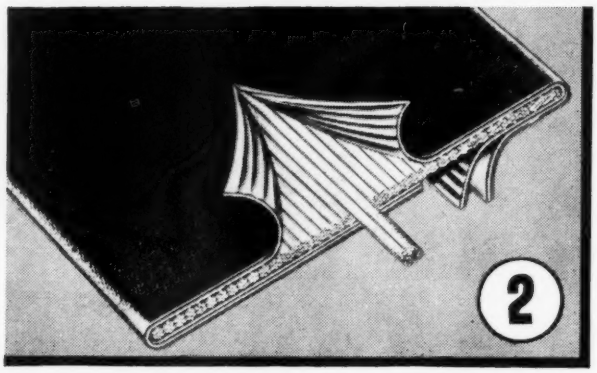

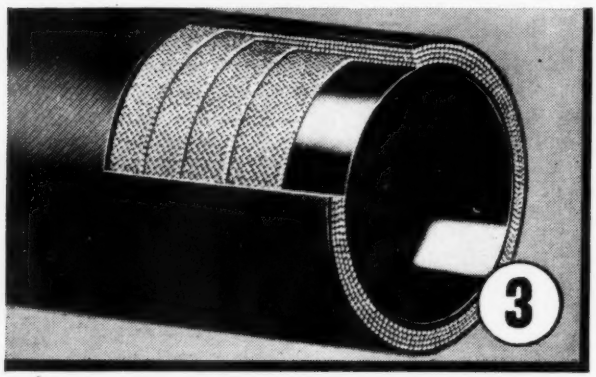

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Port Economics

Part 8. Administration and Operation

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IN earlier chapters we have looked in turn at various separate elements which go to make up the economic structure of the port industry. In this way, we have examined the questions of function, hinterland, demand, supply, utility, value, constitution, finance, labour and charges. It may be useful now to stand back, for a brief space, from the detail and try to see the port economic picture as a whole. Let it be remembered, once more, that the economic angle is only one of a number open to an objecjective observer. We shall do well, therefore, to remind ourselves of what it is we are trying to see. The opening sentences from Alec Cairncross's " Introduction to Economics " (Butterworth and Company Limited, London) will help us to keep our mental vision correctly focussed for our present purpose.

" Economics is first and foremost a study of human behaviour. So, too, are many other subjects—ethics, politics and psychology, for example. What aspect of human behaviour is the special point of departure of economics? A preliminary answer is that economics studies the part played by money in human affairs. It is about money and the things that can be bought and sold for money; how men earn a living and what sort of a living it is that they earn. And it is about the way in which money affects our way of life and our outlook on life. If we probe a little deeper, however, we find that economics is really not so much about money as about some things which are implied in the use of money. Three of these—exchange, scarcity and choice—are of special importance. Let us take them in turn."

Very well—let us take them in turn and try to apply them to the administration and operation of docks and harbours.

The doctrine of exchange.

When an economist watches a man spending a pound he is especially interested in what that particular pound represents in goods or services and what the spender is getting, by way of new goods or services, in exchange. The port and dock authorities of the world spend a lot of pounds in one way and another, and the point for us is what those pounds stand for and what is obtained or provided in exchange for them. In Chapter 5 we saw how a port and/or dock authority normally obtains its pounds and also what it does with them. Summarising very briefly, we may say that it gets the money from shipowners, importers, exporters and lenders; and—quantitatively speaking—from a variety of less important sources. The money paid by the shipowner is part of the price he has obtained for past services rendered in carrying traders' goods or in carrying passengers across the seas of the world. He gives up part of that price—and he pays it over to the port or dock authority. In return he gets the use of port and dock facilities for his ship. The port and dock authority, on its side, has had to obtain and spend money to create and to maintain the facilities and it must go on obtaining and spending money in order to complete the task of paying for the facilities and to preserve them in an efficient state. The money borrowed from those willing to lend it represents goods and services of every description which have been changed into cash and canalised into the hands of the port authority—most often through the agency of investment brokers. By such means, for example, some of the carefully-saved pay and pension of an Army Officer, given to him in exchange for his services to the Crown, is borrowed by a port authority, placed together with other borrowed money and turned into new piers, quays, cranes or dredged channels for the accommodation of shipowners and traders. For the use of the money, the port authority pays the lender an agreed sum by way of annual interest and it obtains funds to do so by hiring out its facilities to shipowners and merchants and, in some cases, by performing labourage services for them. From the same sources, it seeks to obtain and accumulate sufficient funds to pay back the borrowed money in due course. Thus the monetary transactions of a port or dock authority are no exception to the general rule that every such transaction is, in reality, an exchange.

Scarcity.

Money itself must be scarce and will only be offered for commodities or services having themselves a degree of scarcity. If there was an unlimited and universal supply of money it would be useless; and if all goods and services abounded everywhere nobody would offer scarce money for them. This quality of scarcity produces planning in the laying-out of our resources. The plans may be one man's private plans as to how he proposes to spend his money, or they may be agreed community plans, or regional plans, or national plans. Again, these influences may all be present together; a man, or a group of men, may plan the expenditure of money in order to obtain and use certain commodities but they may find their plans deflected, restricted or even made impossible by civic, regional or national plans impinging upon their private plans. All this springs from scarcity — scarcity of money and scarcity of the things represented and obtainable by money.

Because money is scarce and because a port authority must obtain a continuous supply, it must provide facilities or offer conditions which will attract money payments. In an entirely free market, the facilities and conditions would have to be as attractive at their particular price as the best available at any other port—but, as we have seen, the market in port facilities is by no means entirely free; quasi-monopolistic and limiting factors are normally present and, in consequence, port and dock authorities often succeed in obtaining money payments from shipowners and traders for the use of facilities which are not necessarily the best in the world or even in the country but which are, on balance, the most convenient for particular vessels and particular cargoes owing to the special combination of a number of circumstances.

Again, it is in the light of the scarcity of money and of the things that money represents that port and dock authorities must administer and operate their undertakings. It follows that all of them cannot do all the things they would like to do, at the same time, everywhere. They must plan the outlay of their individual resources, and, moreover, their separate programmes and organisations are often subject to the requirements of an over-riding national budget or licensing scheme or system of controls.

Choice.

All free spending—that is, all free exchange—implies choosing. In a heavily-taxed and tightly-controlled community there is less free exchange and therefore less exercise of personal choice than where taxes are trifling and state intervention small. In the United Kingdom, one third to one half of the national income is absorbed by taxation. The balance is spent by individuals and groups of people as a result of a continuous process of comparing and choosing. The economist must assume—not because it is always true but because the assumption is necessary—that every such choice is self-interested and rational.

Port and dock authorities are in a special position. Their spending is not motivated by self-interest in the narrow sense but they frequently have the local community interest in their minds and also the general interest of their country. Because their governbodies usually consist of a number of members—anything, say, from ten to forty—and because such members are drawn from different walks of life and their services are generally unrewarded, and because their administrative aim is not profit but public service, when they exercise choice—as they must often do—in spending their resources, their aim is to secure the highest general good rather than the maximum private satisfaction. The broad divisions of port expenditure inevitably " choose " themselves—it is in the

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matters of emphasis, timing and quantum that choice is most commonly exercised. No port or dock authority could continue to function without spending some money on the two objects of administration and maintenance. Few could go on for long without adding two more heads of expenditure — namely operation and financing.

Administration.

Undertakings providing port facilities range from the small town quay to the great ocean terminal. We have seen that, generally speaking, such undertakings came into being when natural conditions ceased to be good enough. An authority was set up to improve and control the facilities and to make charges for their use; and the authority's first need was for trained and professional men to offer advice upon policy and works and to carry them out if approved. The town quay sometimes requires only a quaymaster and collector of dues; the great seaports of the world normally require a general manager, an engineer, a harbour and dock master, a traffic manager, a secretary, an accountant, a dues collector, a commercial superintendent, and a solicitor—each having such assistants or deputies as may be necessary and staffs adequate to deal with the volume of the work. This subject is considered in some detail in the companion volume (Port Operation and Administration—Chapman and Hall) and the reader is referred in particular to Chapter II—Internal Organisation.

Maintenance.

The economic aspect of maintenace may be simply stated. Unless an undertaking can earn and is willing to spend a sufficient essential minimum sum on the repair and necessary renewal of the facilities, they will lapse into obsolescence or decay and, finally, if the process be not checked, the undertaking will cease to exist. At the other end of the matter, if the undertaking spends regardlessly upon maintenance so that administration must suffer (leading to weak control), or commercial effort must be lopped (leading to trade stagnation), or operating becomes less efficient (leading to dissatisfied traders), or financing is curtailed (leading to overcapilization and/or the abandonment of improvement schemes), then the authority may find itself with a well-maintained, old-fashioned undertaking but with little or no traffic to handle. It is in this sphere that the economist's twin theories of scarcity and choice apply very particularly to port administration and operation.

The burden of maintenance varies with the type of undertaking. A body which is wholly or primarily a river conservancy is principally concerned with dredging, the upkeep of piers, breakwaters and lighthouses, the care of river banks and the due maintenance of its craft. An authority which, in addition to carrying out conservancy duties, also owns and operates enclosed docks, must spend money regularly upon dock gates, lock entrances, quay walls, roads, railways, bridges, cranes, locomotives, wagons and many other such items.

Operation.

In dock and harbour language, the word operation is used most often in connection with cargo handling but there are other tasks which come under this general head. Lighthouses must be manned (or their controls attended to), signalling systems require working, lock gates must be opened and closed, bridges swung, the premises watched, dock railways worked and ships assisted by dock pilots. But in ports and docks where the authority undertakes cargo handling, this item usually accounts for a large part of the total operating expenses of the undertaking. The expenditure consists almost entirely of wages paid to dock workers and is recoverable from shipowners, and/or traders. The economic basis of such transactions has been discussed earlier.

Financing.

Generally speaking, port and dock authorities set about the task of improving or extending their facilities by borrowing money from the investing public upon the security of the undertaking's revenue and by promising to pay an agreed rate of annual interest and to repay the principal after an agreed number of years. Scarcity and choice are again very evident here. Every authority desires to keep its facilities completely up to date and to extend them to the utmost limit of its trading prospects. Every authority also desires to keep its charges attractively low in order to encourage trade and thus render the greatest possible service to shipowners, importers, exporters, local industrialists and its surrounding population. But low charges may mean a low gross income; and it is out of income that money must be found every year to pay the interest on existing unextinguished debt and upon new money borrowed or proposed to be borrowed to finance improvements and extensions and also to make sinking fund contributions with a view to the reasonably rapid amortisation of public debt. At the same time, income must also take care of maintenance, administration and operation. Faced with these many and various possibilities, the average port authority is in little danger of failing to appreciate either that money is scarce or that the exercise of choice is a continuous and often anxious necessity.

Specialist ports.

Among the number of the world's seaports there are some which are especially associated with particular trades or functions and, inevitably, such specialisation has its economic aspect. The greatest ports of all are commonly capable of dealing with anything—ships of practically any sort or size and cargoes of all descriptions; and, within the extensive areas of their jurisdiction, it is customary to find a number of different docks, lengths of quay and even satellite ports—many of them particularly designed, equipped and set apart for one type of trade. In a sense, however, the very greatest ports also tend to be specialists in two ways—they are usually the great liner ports and often ocean-passenger ports. The leading ocean liner companies own and operate the crack passenger vessels, very large cargo vessels carrying passengers as well, and other ships which are purely cargo carriers. But the specialist ports which spring most readily to mind are the bulk oil loading terminals, the ore loading ports, the coal shipping ports, bunkering stations, fishing ports and the great shipbuilding centres. Also, there is a degree of specialisation in coal and ore discharging berths, bulk grain ports, cold storage terminals and in places which can handle unpacked fresh fruit, such as stems of bananas. In the early years of the petroleum age, bulk oil discharging ports also regarded themselves as specialists but today the provision of oil storage tanks and pipe-line discharging systems is very general.

The first and most vital economic factor for a specialist port is the continued availability and world importance of its special traffic. Specialist shipping ports first arose because good supplies of scarce and valuable products, usually of a primary nature, were found in the vicinity; specialist discharging ports have acquired their character because such products were—and still are—wanted for consumption in their neighbourhood and beyond. Neither the mineral wealth nor the food-producing capacity of the earth are inexhaustible and it is a matter of history that some deposits have been worked out and new ones have been sought and discovered in far distant places. Specialist ports are also extremely sensitive to industrial disturbances and the consequent dislocation or temporary paralysis of traffic; and it may here be noted that upsets of this sort, intended to be temporary, can sometimes result in permanent injury to a trade. Again, the fate of a specialist port may be closely affected by international tension, rivalry or disagreement; and, lastly, the advance of science and technology may possibly have an important bearing upon the future development of such places. The prudent policy would appear to be to broaden the traffic basis wherever that course is possible; and, where it is not, only to spend large sums on specialist port development, where the material to be shipped is known to be in great supply, political and industrial conditions are settled and stable, and the future world market for the commodity is firmly assured. These conditions represent the ideal; it is not suggested that they will often be found. Insofar as they may be lacking, business enterprise, courage, organisation and risk-taking must normally bridge the gap.

The shipbuilding industry flourishes at a number of ports and is often found in association with marine engine building, ship repairing and drydock operation. These are industries of high importance—to the nation at large and to the working populations of the ports where they are established; but it is probably fairly

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generally true to say that, taken by themselves, they never supply and never could supply an adequate economic basis for the creation and proper development of a modern port. Thus it is that the world gets its new ships from places which largely depend for their existence as seaports upon cargo and/or passenger traffic; whilst the building and repairing industries make such contributions to the port revenues—subject to statutory provisions—as are considered appropriate by the port authority.

There are a number of small passenger ports in the United Kingdom which are almost purely specialist—stepping stones, as they were once described, between the railway train and the steamer; but the principal passenger ports, e.g. Southampton, London, Liverpool, Glasgow, Hull and Newcastle-on-Tyne, are also eminent cargo-handling places. Their special characteristics and the reason for their development as passenger terminals are discussed in Chapter VIII of the companion volume (Port Administration and Operation—Chapman and Hall).

Continuous shifts.

Broadly speaking, when expensive equipment is standing still it is losing money for its owner. Port and dock undertakings are operated night and day, year in and year out, for the reception, moving and sailing of ships—but not necessarily for the loading and unloading of their cargoes. In the United Kingdom, cargo working normally continues between the hours of 8 a.m. and 5 p.m., for 5½ days out of the 7 in every week, but two-shift working, that is from 6 a.m. to 10 p.m. is sometimes resorted to. Also, overtime working is often adopted in the evenings, on Saturday afternoons and on Sundays. In circumstances of great urgency, three continuous 8-hour shifts may be worked, thus keeping a ship going day and night. For registered dock workers and for many other dockside grades, all hours outside 8 a.m. to noon, and 1 p.m. to 5 p.m., rank for overtime pay—usually one-and-a-half times the basic rate for weekday overtime including Saturday afternoons and double rate for Sundays. It is the laid-down duty of a registered dock worker to work reasonable overtime upon request and proper notice.

It is sometimes urged that continuous shift working should be much more widely practised in the United Kingdom than is at present the case; and unfavourable comparison is often made with Continental ports where the system is common. Clearly, a substantial extension of the regular hours of working would accord very suitably with the objective of increased mechanisation. The machines would have a better chance to justify their cost; and as their use should make work less laborious, the workpeople might be agreeable to work extended hours, if required, at appropriate rates of pay. Continuous shift working, however, involves problems of labour supply, co-ordination with other arms of transport, the availability of adequate transit shed and warehouse space, and a number of other requirements which are referred to in the note on turnround which now follows.

The turnround of shipping in U.K. ports.

The quayside operational aspects of turnround were dealt with in pages 166 to 170 of the companion volume (Port Operation and Administration—Chapman and Hall) to which the reader is referred. Some wider aspects of turnround were reviewed in the report of a working party on the Turnround of Shipping in the United Kingdom ports submitted to the Minister of Transport in May 1948; and the subject is now (July 1952) under review again by a Ports Efficiency Committee, appointed by the present Government, under the chairmanship of Lord Llewellin. The 1948 report began by remarking that turnround was being adversely affected by (1) unrepaired war damage in the ports (2) the wartime losses of medium-sized ships (3) great concentration of traffic on some ports and the neglect of others and (4) the shortage of railway wagons. It was noted, in particular, that there were delays to ships discharging food, timber and iron ore. The working party recommended (1) priority for port works, including warehouses (2) rapid clearance of transit sheds (3) greater use of ports not working to full capacity (4) simplification of " marking " of goods (5) the extension of double-shift working (6) co-ordinated planning of import programmes as between the responsible Government Departments, the Transport Commission and the Labour Board (7) the setting up of Port Operations Consultative Panels to function by general consent in the principal ports (8) the development of mechanical cargo-handling (9) swift release of ore wagons at iron works (10) greater flexibility as between nominated receivers of iron ore cargoes (11) revision of charter parties to eliminate delaying features (12) urgent attention to the ports' needs for more cranes, mechanical aids and spare parts (13) development of canteen, medical and welfare services for dockers (14) more pieceworking in connection with mechanisation (15) more night-shift working with fresh gangs (16) a training scheme for checkers (17) more statistics to facilitate the study of port operations and (18) the removal of unreasonable practices by consultation between employers and workpeople.

More than four years have passed since the working party's report was submitted and the reader will have gathered from previous chapters in the present study (and from the companion volume) that some of the above-given recommendations relate to old problems of considerable complexity, that others were of a temporary nature inseparable from the aftermath of war, and that yet others have since received special attention with valuable results. The economic ideal is that a ship should always be moving; the inevitable and practical truth is that she must sometimes remain fast in port. It is everybody's wish that she should be received, berthed, discharged, loaded, bunkered, stored, watered, dry-docked, surveyed, repaired and sent to sea again in the shortest possible space of time consistent with her size, her cargo and the extent of her requirements in port on any particular occasion. It is safe to say, in every week that passes, some instances of remarkably good turnround occur, as well as others that are not so good and some that are bad. Thousands of people and dozens of organisations are concerned, some in this country and some overseas. There is no universal specific for good despatch and no outstanding single reason for poor performances. The subject has received and is still receiving intensive attention—not only from men who have spent all their working lives in the port industry but also from new and ingenious thinkers. One of the latter recently suggested that ocean cargo-carriers should be constructed in two detachable parts—a propelling section and a carrying section, the latter of which should be duplicated so that the ship could arrive, leave her loaded cargo section, take on a loaded cargo duplicate, and proceed to sea at once leaving the inward cargo to be discharged and an export cargo to be loaded whilst the propelling section was crossing and re-crossing the ocean with other cargo. The reader may think that this might not prove to be a complete solution of the turnround problem but it is perhaps some slight evidence that general interest is certainly being taken in the question and we may hope that combined thinking and combined effort may yet lead to important results.

In particular connection with the question of statistical records, the student is referred to pages 256 to 261 of the companion volume, where the subject is treated in some detail. One piece of homely advice is there offered which may perhaps be appropriately repeated here. Statistical records should be carefully planned in the first place and should be regularly used for some valuable purpose. As soon as it is discovered that nobody uses them they should be discontinued at once.

(to be continued)

Mechanical Equipment for South African Ports.

According to a recent announcement in the " Cape Times " the South African Railways and Harbours Administration proposes to spend £100,000 in the present financial year on mechanical handling equipment as part of an extensive programme to improve the handling of goods on the railways and in the harbours. The fork-lift pallet system of working has been introduced at all the principal ports, and at present 23 fork-lift trucks, each costing about £1,500, are in service, and delivery of a further 14 is expected soon. The Administration states that it has been hampered by the difficulty of getting delivery from overseas of equipment already ordered, and estimates that it would also require the expenditure of about £100,000 at each port to effect any appreciable improvement in the rate of cargo handling. New cranes and equipment such as grabs for handling bulk cargoes are urgently needed.

Use of Timber in Docks and Harbours

Factors in Favour of Wood for Port Works

By R. P. WOODS, B.A.For. (Cantab.)
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A SURVEY of the docks and harbours of the world will show a preponderance of timber structures, although concrete has been used in the past and is at present being used for a number of new works. The relative merits of these two materials must be taken into account when new structures are contemplated, but provided the right timber has been selected and also that the correct treatment has been specified, the advantages of timber will show clearly on the credit side. No two ports can be considered alike in their requirements and neither can two coasts, but for those interested in the relative merits of timber and concrete attention is drawn to the paper presented to the Annual Convention of the Association of Pacific and Far East Ports by H. W. Frith at Vancouver in August, 1931, in which this problem is discussed.

Uses of Timber.

There will always be a demand for a material which can be cut to size, shaped or altered in situ with little trouble, and is comparatively cheap, and timber, which fulfils these requirements, has long been used in the construction of docks, wharves, etc. It has been employed for a variety of purposes from piling to dock gate construction, and will continue to be used in this field due to one major factor—its resilience to impact. For this reason damage to craft and structures is considerably minimised when timber is used, and it is noticeable that to-day composit structures are being erected where the advantages of both concrete and timber are employed according to the requirements of the situation.

Fenders, walings or rubbing pieces, piles, lock gates, keel blocks and wedge facings, decking and nosings are only some of the many uses to which timber is put. Under the jurisdiction of every Dock and Harbour Authority, repairs to boats, etc., also take up a large quantity of wood of various types, but the scope of this article will be restricted to the use of wood in wharf construction. In 1938 it was estimated that in a year's maintenance seven different authorities absorbed 188,414 cu. ft. of timber, the three railway authorities owning docks used a total of 169,745 cu. ft. and the amount of timber used by four major dockyards of H.M. Navy was 308,218 cu. ft. These figures show a surprising volume of timber being utilised for constructional work of this kind.

Species of Timbers Used.

The very nature of the work for which timber is used in wharf construction usually calls for constructional members of large sections and long lengths, and this in turn governs the types of timbers which are available to meet these requirements. The presence of destructive agents, whether mechanical or natural, also affects the species chosen since there are very few that are naturally resistant to the marine borer. Thus, when one examines records of the types and kinds of timbers used, it will be seen that there is a constant repetition of the same species.

The shortages occasioned by the war, and also to a certain extent by the overcutting of selected timbers, has resulted in a search for new woods which will meet the requirements of this trade and several timbers are proving themselves resistant to teredo and, to a certain degree, limnoria.

Being a timber-importing country Great Britain is at a disadvantage when compared to such timber-producing countries as Canada, U.S.A., Australia, Africa or India. This results in a limitation of species used, which in its turn is affected by the lengths and sizes available. When we consider that in a recent survey only the following timbers are recorded as having been used for piling in this country :

Memel redwood, greenheart, pitch pine, Douglas fir/Columbian pine (pressure-treated)

and for other uses in dock and wharf construction :

Elm, oak, jarrah, pyinkado, karri, brush box, larch, beech, blue gum

it would seem to imply that these are the only woods available or suitable. That this is erroneous is indicated by the fact that the following timbers are used for similar purposes in Australia alone :

Turpentine, ironbark, grey box, tallowwood, jarrah, yellow and white stringybark, white mahogany, brush box, southern blue gum, grey gum, satinay, red bloodwood, red gums.

In the case of the first eleven timbers, these are always pressure-treated, while the last two are used in an untreated condition.

Turning to India, one finds that the following woods have proved suitable for such work, namely :

karen wood, jarul, thitsi, sal, thande laurel and pyinkado for piles, with teak and sal for beams, etc.

It is of interest to note that greenheart and jarrah were tested for resistance against teredo and were both reported to be heavily attacked. The experiments in Shoreham Harbour carried out by the Timber Development Association have confirmed these findings with regard to jarrah.

Africa, which at present proves the main source of hardwood for this market, yields many which would prove suitable for this type of work, and some of them have already been used, for instance :

Ekki, okan, afzelia, limbali, niove, opepe and tali.

Ekki in particular has been widely used in French ports and is extremely durable and available in very large sizes.

The resources of South America are vast but unknown. Tests are being carried out on many hitherto untried timbers, but **angelique/basra locus, greenheart** and the **guayacans** are some of the more familiar woods from this part of the world that have been used in this field. The main requirements are durability, resistance to marine organisms of a wood-destroying nature such as *Teredo, Bankia, Xylophaga* and *Limnoria*, a long bole and an ability to withstand pile driving. In addition to those already mentioned, **black kakeralli, determa/wane, piquia, tatajuba and tuary** all come into the category of suitable woods. In view of the latest developments in British Guiana, **black kakeralli** may well be remembered, as can **determa/wane** and possibly **tatajuba.**

It can thus be seen that one is not necessarily confined to pitch pine and greenheart as the only timbers suitable for this purpose; there are others available, and it will surely be only a matter of time before they become available in this market.

Sizes of Timbers.

It is only natural that when one considers the nature of the structures — wharves, lock gates, piles, fendering, etc. — one expects massive members. With regard to piles, such dimensions as 14-in. x 14-in. and from 35-ft.—60-ft. in length require considerable work to obtain, since this involves the finding of suitable trees, the difficulties of transportation from the forest, and the subsequent shipping to their destination. A recent survey of dock and harbour authorities in the United Kingdom shows a considerable variation in the sizes of piles used, and the maximum size reported was for bearing piles 70-ft. x 12-in. x 12-in. and 70-ft. x 18-in. x 18-in. The range in size was from 22-ft. x 14-in. x 14-in. to 40-ft. x 9-in. x 9-in. and lengths up to 70-ft. were mentioned. Rubbing pieces or fenders were up to 28-ft. and 30-ft. in length, and the sizes were 12-in. x 3-in., 8-in. x 6-in., 12-in. x 12-in., 3-ft. x 11-in., etc., and varied according to whether they were placed horizontally or vertically.

Use of Timber in Docks and Harbours—continued

Dock and lock gates, usually constructed from greenheart, showed a considerable variation in dimensions of the timber. Mitre posts and heel posts required the largest sizes, such as 22-in. x 22-in. or 14-in. x 14-in. up to 24-in. x 24-in. for a heel post. One detailed construction cited the following :

Heel posts—30-ft. x 12-in. radius half-round logs.
Clapping cill—28-ft. 6-in. x 18-in. x 12-in.
Mitre post—30-ft. x 12-in. x 9-in
Sluice door—6-ft. x 6-ft. x 12-in.

Other undefined uses were 20-in. x 20-in., 24-in. x 10-in., 24-in. x 24-in., this last for ledges, and 18-in. x 15-in.

Deckings varied considerably, the only definite size quoted being 11-in. x 3½-in., though it is probable that the majority used 5-in. x 2½-in.—3-in. The sizes mentioned will indicate the great difficulty which is experienced in obtaining timber of these dimensions, and the tendency to use steel for the construction of these gates can well be understood. A form of construction using a composite pile was incorporated in the wartime ports of the Gareloch and Loch Ryan, where 40-ft.—50-ft. of reinforced concrete piling 14-in. x 14-in. had a long spliced 24-ft. timber section by means of two ½-in. steel plates 8-ft. long; 14-in. x 14-in. fendering was also used with 12-in. x 6-in. waling. The composite pile did not prove economical in handling, but it can be cited as an example of using both materials to the best advantage. Full details of this have been reported in the Civil Engineering and Public Works Review, volume 44, No. 513.

American practice has shown a greater use of timber, primarily due to the fact that the United States is a timber-producing country. Preserved timbers are used extensively. Details of a fuel wharf 450-ft. x 24-ft. with a connecting pier 300-ft. x 20-ft. have been published. Six hundred Douglas fir piles 65-ft.—75-ft. long were used, and the decking utilised 4-in. x 12-in. joists and 3-in. plank decking surfaced with 2-in. x 6-in. planks laid parallel with ¾-in. open joints. Trestle construction was used throughout with preserved dolphins at 55-ft. centres on both sides of the wharf. Each dolphin was made up with 24 piles, so that it can be seen that a colossal quantity of timber was used—in fact, 43,000 lineal feet of piling was used, together with 154,500 B.M. of pitch pine for the decking and framing. Numerous other examples can be quoted where large quantities and big sizes of timbers have been employed.

Ekki piles, driven August, 1951, at Hermitage Wharf, Wapping, London.

Durability and Preservation of Timber.

The natural durability of timber varies according to the species, and in this respect resistance to deteriorating agencies, especially marine borers such as *Teredo*, is confined to a very few woods. In many instances even those timbers reputed to be resistant will eventually succumb to the onslaught of this mollusc, so that it becomes necessary to increase their resistance by other means such as the application of a preservative. These may be divided into three main types :

(1) Tar oil,
(2) Water soluble,
(3) Organic solvent.

Each of these types has its advantages and disadvantages and consideration must be given to the use to which the timber is to be put. The following table gives some examples of suitability of these types :

Class of timber or structure	Coal-tar creosote type	Water solu on types	Organic solvent types
Railway sleepers ; transmission poles ; marine piling ; fence posts ; pergola poles ; bridge timbers; wood block paving ; coal barges.	The most suitable preservative. Best results with pressure impregnation, but open tank process also suitable. An impregnation method is essential.	Some which are fixed in the wood are suitable, but the more leachable are unsuitable.	Expense generally rules out this type
Wooden farm buildings ; timber garages and outhouses ; fencing above ground level; pigsties; chicken houses ; weather boarding.	Quite suitable and frequently applied to boarding by brush. It is not advisable to admit animals to freshly creosoted structures.	Many of these are quite suitable.	Generally suitable.
Factory roofing timbers ; housing timbers ; shipbuilding timbers ; motor car bodies.	Not as a rule suitable, but sometimes used where objections do not arise.	Generally suitable.	Generally suitable.
Timber for horticultural uses such as seed or bulb boxes and glasshouses.	Not suitable if timber is in contact with plant.	Generally suitable.	Generally suitable.

Until recently the coal-tar derivative, creosote, was practically the only wood preservative used for piling and dock construction, but others of the water soluble type have now been used although it is early yet to state how these will stand up to such conditions. Although they come under the title " water soluble " they are in the fixative category, if such a word can be used, in that some of the salts of which they are composed are deposited in the wood elements and are thus integrated into the wood. Tests have proved that one of these preservatives has been quite resistant to teredo. It can be said, however, that the full cell process of cresoting piles, etc., is the most commonly used. The amount of creosote used in the naval wharf referred to was 14 lbs. per cu. ft. for the piles, 12 lbs. per cu. ft. for the decking material, and sway bracing, clamps, etc. had 16 lbs. per cu. ft., which is the standard specification of the American Wood Preservers' Association.

Creosoting in the United Kingdom is carried out either by the Full Cell or Bethel Process (which, as the name implies, more or less fills the cell spaces of the timber of the impregnated wood with cresote) and the Rueping Process. This latter process differs from the Bethel Process in that the timber is subjected initially to compressed air followed by the introduction of the creosote at a higher pressure. The compressed air in the cell spaces, on release of the subsequent pressure, " kicks back " the creosote from the cavities, thus preventing " bleeding " in subsequent use. It is not recommended for marine use as the Full Cell Process gives better results, but for transmission poles or wood block paving it is to be preferred since little or no " bleeding " occurs.

With refractory timbers, i.e. those which resist the penetration of creosote such as Douglas fir/Columbian or Oregon pine, spruce,

Use of Timber in Docks and Harbours—continued

etc., it is essential that they should be incised. This consists of passing the timbers through rollers having a series of small knives which must penetrate all four faces of the timber to a depth of ⅜-in. at intervals 1-in. apart. The minimum amount of creosote to be absorbed by the timber varies according to the species and purpose to which the timber is to be put and is laid down in the B.S. 913—1940 entitled "Pressure Creosoting of Timber." A general table of the permeability of different timbers will be found in the "Handbook of Empire Timbers" and also the Timber Development Association's red booklet, "Timber Preservation."

A wharf, a dock gate, or a pile structure can be designed scientifically to carry practically any load, but all the work can be made valueless by the depredations of various destructive agencies which live in the sea or by the movement of sea water, etc. These marine pests are found all over the world from the Arctic Circle down to New Zealand and Australia, and their liking for timber has been known and written about since the times of the Greeks and Phoenicians. All salt or brackish water possesses one or more forms, and the intensity of attack tends to increase in tropical waters with a greater variety of types of pest, although they all fall into two main groups—Molluscs and Crustaceans. The first group are the most serious since they include the best-known type, the *Teredo* or shipworm. It was originally believed that this pest merely used timber, whether static or mobile as in a ship, as a developing ground, and that it fed on microscopic organisms in the water which it absorbed by means of siphons, but it is now known that it possesses an enzyme which breaks down the cellulose content of the wood which then nourishes the teredo. Its work may first become apparent by the collapse of a structure, since the entrance holes are minute and give no indication of the size of the worm within the timber. The worm will vary in size from ⅜-in. in diameter to 1-in. and from 6-in. to 4-ft. 6-in. in length. The teredo galleries are lined with a calcareous deposit which is a sure indication of its identity. *Bankia* spp. and *Xylophaga* spp. show a larger corrugated bore-hole which is rarely lined with a deposit. In case it is thought that only wood is attacked by marine borers, it is interesting to note that *Pholadidae*, *Martesia* and *Lithophaga* are known to attack rocks and concrete.

The Crustaceans, including *Chelura*, *Sphaeroma* and *Limnoria*, of which the latter (also known as the sea louse) is the most destructive, are very widespread. As their name implies they are of the lobster, shrimp and crab order. They all carry out a similar type of damage, namely the gnawing of a series of interlacing galleries in the surface of piles and planks which can be as many as 200—300 per square inch. The attack penetrates ⅛-in.—¼-in., but since the wood is left in such a fragile condition the action of waves or rubbing of a boat easily breaks it away thus exposing fresh areas for attack, until eventually the pile or member is literally fretted away between the high water and mud levels.

There is still much to learn about the life history of these pests, since infestation will vary according to many factors about which little is known. Attacks will suddenly start and cease and species will change, but it is known that salinity, temperature, water depth, pollution and dissolved oxygen and hydrogen ion values all affect the occurrence of these attacks; it is advisable to consult the marine biologists and other sources to determine the risks to new structures. As has been stated pressure treatment or the use of a resistant species are to be recommended.

Where treated timbers are used, the greatest care must be taken to ensure that the treated surface is not damaged before placing the timber in the water. Where possible all boring, etc., should be undertaken before treatment, and if it is essential to cut after treatment all freshly exposed surfaces should receive additional protection, because it has been found that the smallest hole or mark will be sufficient to permit entry of the *Teredo* or *Limnoria*. Numerous methods have been tried to protect timber from these pests and are discussed fully in an excellent series of articles by Robert D. Chellis in the American "Engineering News-Record" and in other publications. Consideration should be given to the North American practice of using round piles as opposed to the English preference for squared ones. The round pile contains a band of 1-in. to 3-in. of sapwood which readily absorbs preservatives which gives a good solid ring of treated wood to protect the less easily impregnated heartwood, thus considerably increasing the effective life of a pile or similar structure.

Empire Wharf Jetty, Millwall, being redecked with stress graded timber.

Scour caused by the action of currents and waves and their actions upon the sea bed is yet another destructive agency to both wood and concrete structures and is one of the most difficult problems to combat. It is also responsible for a high rate of destruction to marine structures.

The relative merits of timber and concrete structures for marine constructional purposes would require a specialised article, and much has been written on this subject. Attention has already been drawn to a paper given by H. W. Frith to a Convention in 1931, and there is much to learn about the behaviour of concrete reinforced with steeel under the action of salt water. It may seem natural for the writer to indulge in panegyrics concerning timber and endeavour to decry the use of concrete, etc., but it is very noticeable that, to-day, where concrete is used, timber has also to be employed to minimise the damage done to both the vessel and the structure, and perhaps it is safe to say that this elasticity of timber is the greatest point in favour of the use of wood. Other factors in favour of wood are :

(1) Ease of modification and alteration to suit changing conditions of shipping—this is one of the reasons why 549 of New York's 578 miles of waterfront constructions are of timber.
(2) The pile structure does not materially affect the currents and eddies about a wharf as it would if of solid construction.
(3) A good salvage value of material at the end of the structure's economic life, provided it was originally treated correctly.
(4) Costs are generally considered lower than for concrete and other materials. This was true in pre-war days, and in America it was found to be 50%—75% less, but this factor may have changed in the light of to-day's economics.

A mass of evidence has accumulated regarding the non-permanence of concrete structures, and where it has been used for sea defence work any casual observer can see the effect of salt water and waves upon these so-called permanent structures; however, the same remarks can be levelled at those structures of non-treated timber or those constructed of a non-durable wood. The economic life, the change in a port's prosperity and the increase in size of vessels must be carefully considered when the decision is to be made as to the type of structure to be erected.

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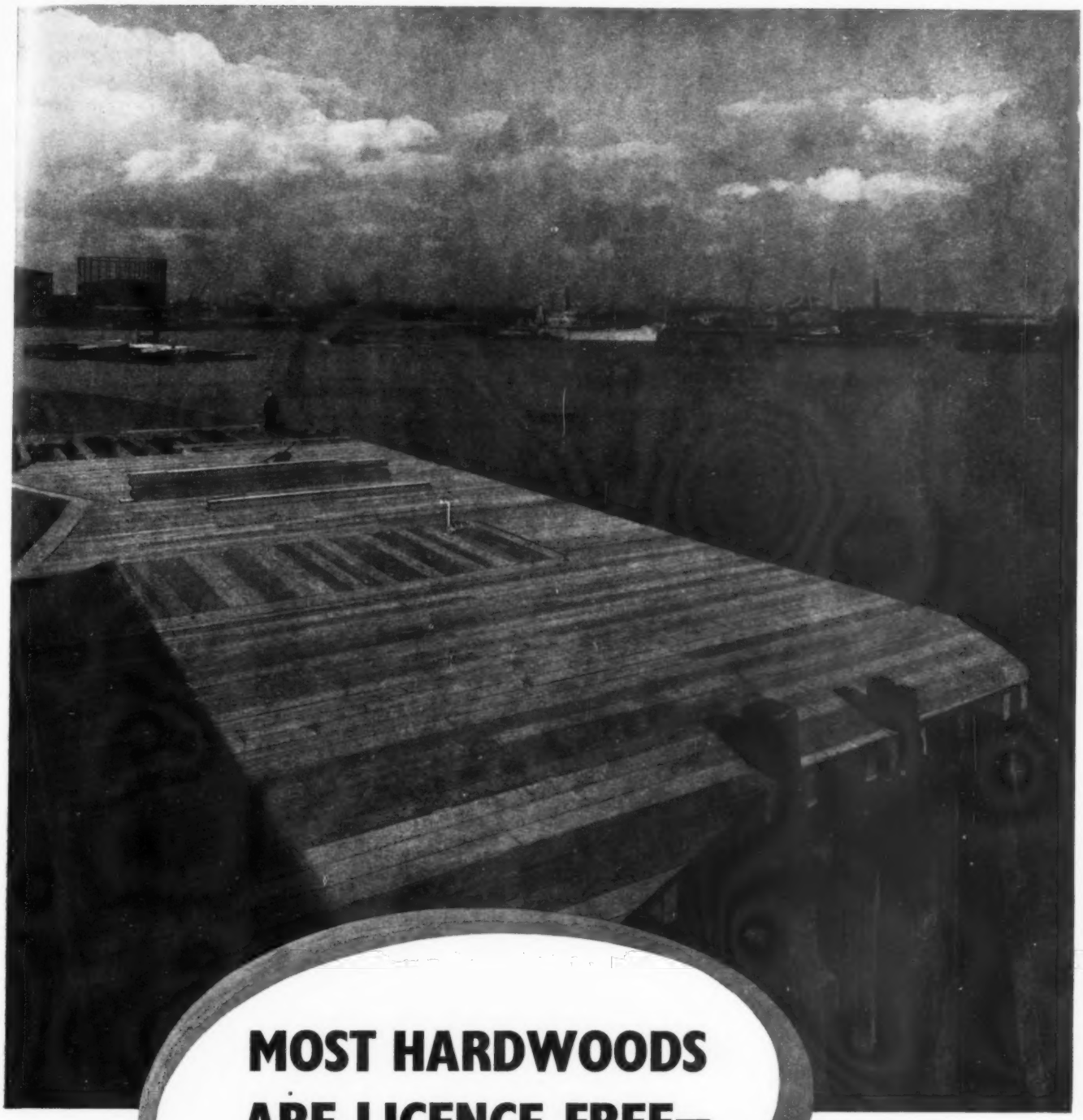

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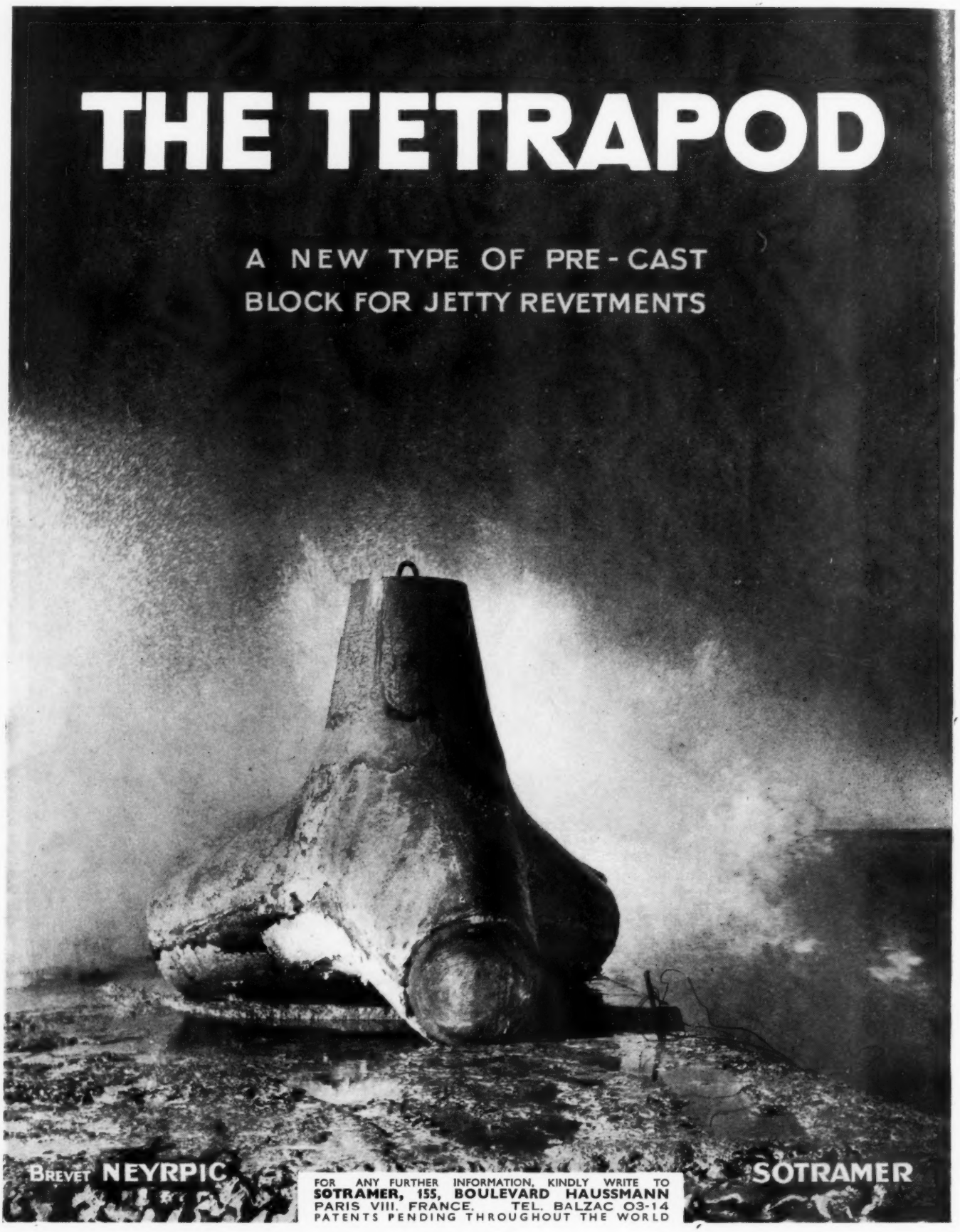

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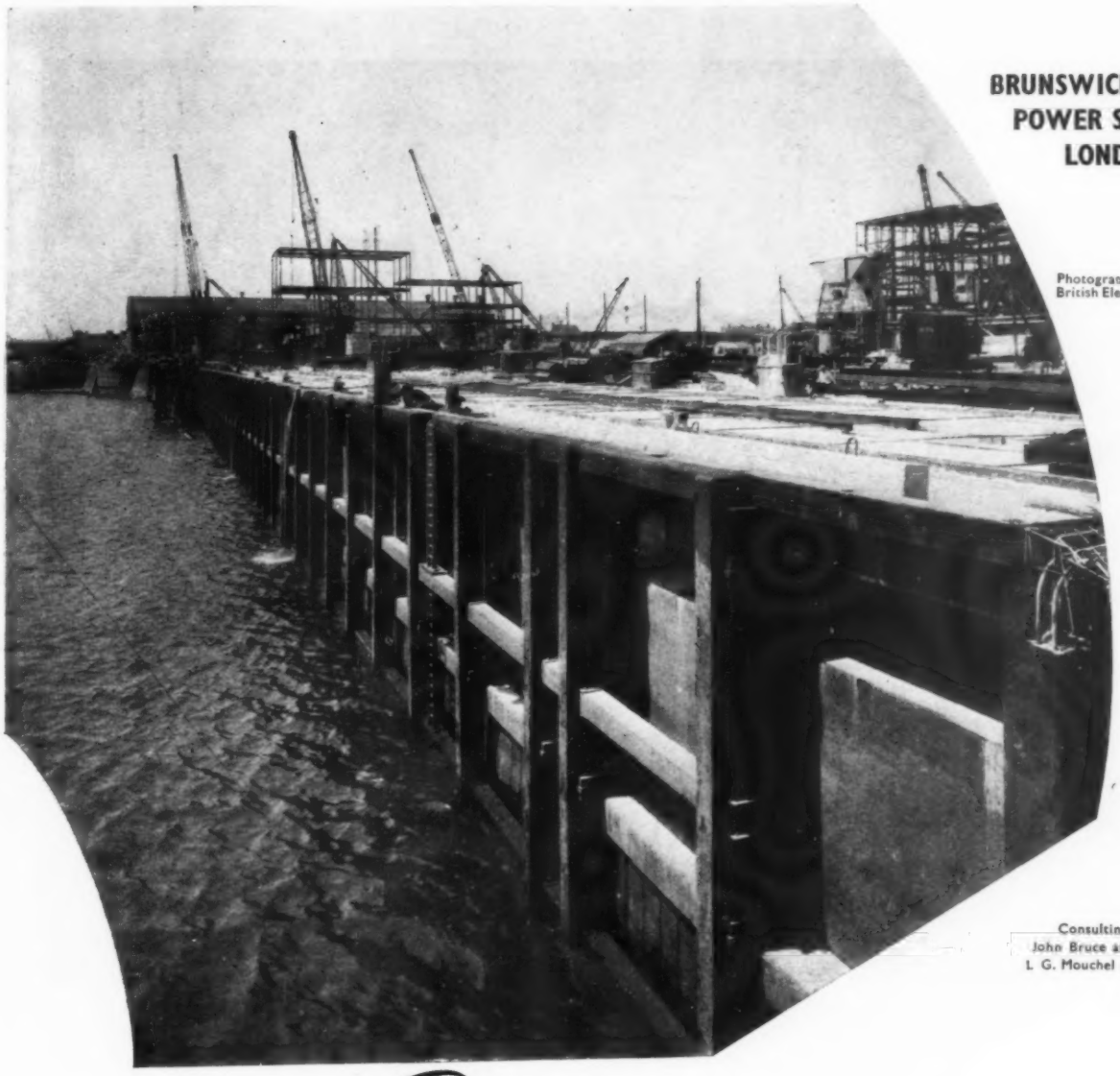

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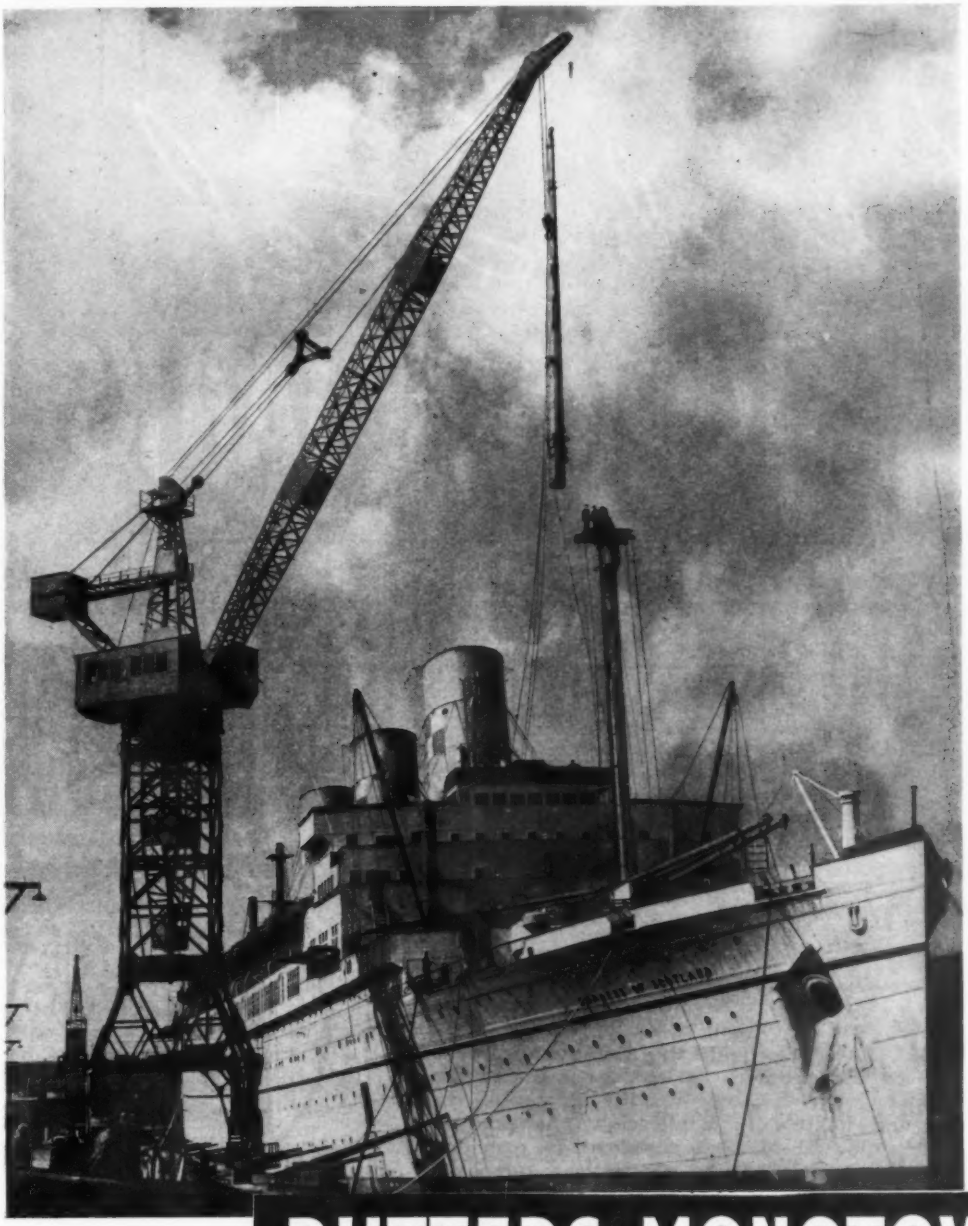

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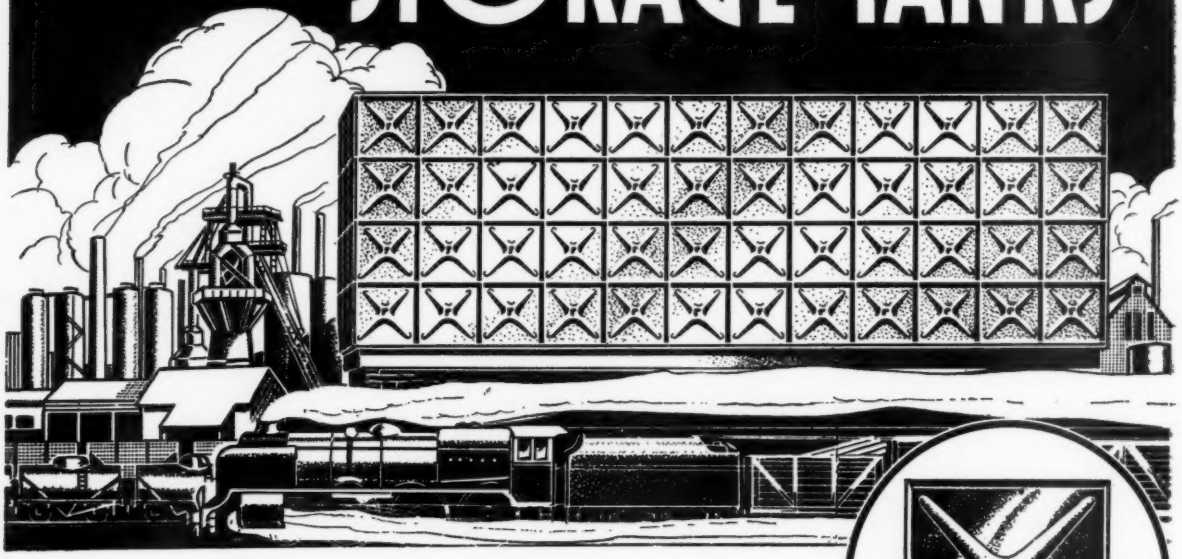

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Navigation and the Harbour Engineer

Need for Co-ordination

By JOHN ANDERSON,, M.I.C.E., M.I.Struct.E.
Harbour Engineer, Aberdeen.

An address was recently delivered at the Annual Conference of the Association of Navigation Schools by Mr. John Anderson, Engineer to the Port of Aberdeen, and as some of his remarks are likely to be of interest to readers of this Journal, we are reproducing the following excerpts, by kind permission of the Association and of the Author.

Introducing his remarks, Mr. Anderson said that to those who go down to the sea in ships, there are, of course, two aspects of navigation—traversing of great stretches of ocean waterway between distant lands, and the more intimate occasions on which they find themselves in Port—the active navigational technique of the helm, the stars and the compass, and the passive geographical influences which dictate the direction of their course; the hazards which have to be met on the way, and the harbourage to which they may return for safety or trade.

The Civil Engineer deals with all the passive aspects related to navigation and transport at the several ports and their approaches forming the ocean terminals to and from which all shipping traffic proceeds. The development of ports has a long historical background upon which it would be interesting to dwell, but it is only in the changes of more recent times that we begin to note the close links between sea transport and navigation problems, and Civil Engineering.

Those who have handled ships know, of course, how important it is that the passage to and from the quayside should be smooth and uneventful from the time the bow is turned towards the sea, but it may be of interest to consider some of the extremely manifold problems which the Civil Engineer has to face to ensure at least that the worst elements of risk in and around ports are removed. He has done much to reduce the hazards of the open sea, where the existence of shoals, submerged rock and dangerous headlands exist, by the establishment, sometimes in the face of tremendous constructional difficulties, of suitable warnings. The erection of lighthouses at sea and laying of lightships' buoys and moorings, and the establishment of radar reflectors near the shore, are all silent but eloquent testimony of the engineer's imagination and skill in the service of the mariner. Such problems have been the subject of technical consideration for centuries, but increasingly so with the introduction of the power propelled vessel and the gradual development of ship dimensions to the point where, as at the larger ocean terminals such as Southampton and New York, vessels have to be catered for up to 1,000-ft. in length, 40-ft. draft and over 80-ft. beam.

These developments have created the need for co-ordinated action and outlook amongst the nations of the world, but it is not generally known that there has been since the latter part of the 19th century, an International Association whose work has been the consideration and unification of the broad technique by which engineers throughout the world may be guided in the conduct of their separate responsibilities in the development and maintenance of their ports. This is called the Permanent International Association of Navigation Congresses whose stated aim is to " promote the progress of inland and maritime Navigation," and there is a British National Committee with its headquarters at the Institution of Civil Engineers, London.

Much useful work is being done, but since major development works are not a daily occurrence because the expenditure involved in the creation of ports and port facilities—creations which are not always directly productive—is very great, it will take a long time to form a pattern of practical international uniformity, if ever.

The urgent need for the rapid turnround of shipping in these days, however, pinpoints the relationship of the more practical aspects of ocean commerce and the need for co-ordination at a high level, not only on consideration of high finance, but—and much more so—on considerations of efficiency, safety and service to mankind.

There are two or three main influences which determine the development of any port, the most powerful being of course, the natural characteristics of the seaboard, the extent of esturial water, and the degree of natural protection afforded by topographical layout. It is with these that the Civil Engineer is chiefly concerned, insofar as he may make use of them in furthering the natural amenities and terminal advantages of his particular territory.

Transport for one purpose or another is, of course, the sole object of navigation, and it is well to remember that this lies behind all the traffic of the Seven Seas, be it for peace or war, pleasure or profit. It has brought into being the need for ships and concurrently the need for ports, the one being the essential complement of the other.

As a Port Engineer himself, Mr. Anderson felt there were many aspects of the creative side of engineering which could be simplified by the constructive co-operation of those whose practical responsibility it is to handle ships, as well as those whose care is the more general direction of their Company's shipping from shore offices. In their respective Company's interests these two groups, the Navigational and the Commercial, collaborate closely but it is seldom that they get together with the designers of ports and port facilities. This may be due to lack of articulate appreciation of each others problems in the past but it need not and should not continue under an active organisation for the advancement of the Art and Science of Navigation as does the Association of Navigation Schools by the promotion of nautical education.

He hoped his presumption in saying this would not be misunderstood because there is much that could be done to bring together,

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Use of Timber in Docks and Harbours

(continued from previous page)

Discussion of a large and complicated problem has been attempted in this article, and it is felt that many points have been omitted. The design and construction of maritime structures is a highly specialised subject in which the engineer, the architect and the marine specialist have to be consulted, but an attempt has been made to show that timber is not by any means an outdated material, and that all over the world there are timbers available and suitable for such purposes while there are new ones still to be found. Experiments and research are continually in progress to find the answers to the questions :

(a) the best woods,
(b) the behaviour of those pests which attack wood,
(c) the best methods of construction and protection against them.

It is felt that the inclusion of a bibliography covering the main sections of this article may be of assistance to those who have to deal with this problem of timber in dock and wharf construction, and attention is again drawn to the various sources of information on timber such as the Forest Products Research Laboratory, the Timber Development Association, the Timber Trade Federation of the United Kingdom and the British Wood Preserving Association, who will readily assist those requiring data on timber.

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Navigation and the Harbour Engineer—continued

even in a curriculum, the two spheres of navigation, viz., active operations and the provision of passive aids to those operations, not only on the electrical and mechanical, but also in the civil branches of engineering.

Dry docks for ship repair, dock gate installations for non-tidal docks, cargo handling facilities, movable bridges to permit the passage of ships through channels which intersect roadways, coal and oil bunkering facilities, etc., are all matters of more than passing interest to the navigator. He doubted very much, however, whether the navigator would consider his views likely to be of interest to the engineer. That was a great pity, because the operator is usually more aware of the navigational limitations of projects than the designer, insofar as they affect his operations. Mr. Anderson often wondered what the navigator would wish to say about this or that scheme, and whether anyone on the practical side of navigation had ever felt it would be worth while for them to study the problems so as to advise on projects, with the authority and backing of a carefully studied and well-established technology of port layout problems to refer to.

As a seaport Aberdeen is quite important, but in times of storm and gales, it suffers from being one of the most exposed positions on the East Coast, and the harbourage itself is very close to the sea. Its problems from the navigational point of view, and as a haven of refuge for shipping, are peculiar to it.

It is, of course, the only sizeable harbour between Dundee and the North, and therefore deserves special consideration in regard to its maritime amenities.

Each port has characteristics and almost a character of its own which are difficult to collate with others. As few are similar in their administration, so no two ports are alike physically—particularly in regard to their approach waters — and even within the harbourage alongside the various quays which he visits, a master is likely to register surprise at the great variety of types he meets, of shed, quay apron, crane and cargo equipment.

Here surely was something on which an exchange of views might be encouraged, as the master could bring to the engineer a wealth of first-hand information regarding other ports of call. Estuarial ports have certain characteristics in common but even these vary in degree according to proximity to the open sea. The traffic which plies them will vary correspondingly. There is considerable difference in the problems of, say, inland ports like Manchester and the Port of London which are quite out of range of the influence of the open sea—except perhaps in the tidal sense, and ports with their quay berths a short distance from the seashore as for example at Aberdeen. The protection, maintenance and development must accord with these conditions as well as the trade which each serves. Many of the important ports of a century ago have faded into insignificance with the decades of changing influences. Some have survived almost entirely by a fortunate and probably fortuitous foresight and willingness of those in authority to meet the changing demands by new, expensive and not directly productive projects. Sometimes, on the other hand, it has been the bitter experience of Harbour Boards to regret the results of carefully considered projects, often because of unforeseeable influences, but sometimes through lack of knowledge and established precedent.

To the shipmaster a new harbour breakwater, pierhead, jetty, quay or landing stage is simply another anchorage to be appraised or criticised according to amenity afforded or some awkward feature presented. He may deplore lack of depth at low water, lack of manœuvring space, inadequate mooring facilities, unavoidable obstructions involving little more care in handling his ship, the need for negotiating difficult passages set at unexpected angles, etc.

Yet these may be the result of much anxious thought on the part of the engineer endeavouring to reconcile, firstly, the limitations of site, the preservation of existing layouts, the difficulties of carrying out regular dredging operations in the way of traffic, the relative importance of land and water areas, uncertainty regarding the type of vessel to be catered for in the distant as well as near future, and many other unknown or variable factors affecting decisions as well as financial considerations of first cost, sinking funds, maintenance and ultimately commercial returns, and secondly, the very technical aspects more particularly involved, e.g., the tidal range, the regime, periodic and seasonal, the exposure of the site, velocity and direction of prevailing, as well as maximum wind conditions, the height, fetch and force of waves, channel silting, coastal erosion, littorial drift of sand.

All of these aspects require long periods of systematic observations and records to aid intelligent anticipation of future trends, and the ultimate fruition of years of accumulated experience and exchange of information among those who specialise in dock and harbour work. And when it is observed that probably 85 per cent. of the total expenditure on port assets is on work out of sight below water level, it will be apprehended how important long term planning is to successful development.

It falls to comparatively few engineers to exercise their professional judgment in the conception, inception and ultimate execution of new schemes of major port development in the United Kingdom but quite large development improvements take place from time to time when it becomes necessary to meet the needs of increasing trade to a port. Construction of new ports and harbours is, of course, being carried out abroad from time to time and these projects are subjects of great interest to the civil engineering profession for they have been for the past century and half the most exciting challenge to engineering skill and courage. But engineering judgment, begotten of even very mature experience, is not always found to be sufficient to cope with the innumerable factors which can influence decisions regarding layout and it is becoming increasingly recognised that a more scientific approach requires to be made to the question of layout. This new approach is gradually taking shape in the form of Research Models of harbour proposals by many different engineers on the Continent, in America and in this country with reasonably encouraging results.

The Isle of Dogs Anniversary

Evolution of West India Docks, London

By W. H. CRAWFORD

In August this year the docks on the Isle of Dogs will have seen their third half century completed, thus assuredly establishing themselves as an integral part in the history of the Port of London. It was in 1799 that the period of gestation commenced in the birth of the West India Docks, one of the parents being an act of Parliament passed in that year. This Act, which was based on a scheme put forward by West India Merchants, authorised the construction of a dock on the Isle of Dogs " for rendering more commodious and better regulating the Port of London," and particularly to secure that " West India produce might be effectually secure from loss by theft or other causes and the public revenue greatly benefited." The Company, formed by the West India Merchants, was granted a monopoly for 21 years to unload and load all West Indian produce brought into the port, while all exports to the West Indies were also required to be loaded at their docks. With such a blessing the growing pains of the scheme were greatly reduced.

The need for a new set of docks were seen many years previous; during the 18th century marked mercantile progress was made. Between 1700 and 1770 the commerce of the port was nearly doubled, while between 1770 and 1795 it again doubled. The congestion which resulted from this rapid progress can be judged from the fact that in the Upper Pool 1,775 vessels were allowed to moor simultaneously in a space established for about 550 vessels. The quays and wharves then in use were totally inadequate to deal with the quantities and varieties of cargoes deposited on them. River thieves enjoyed the good business of plundering the sheds and lighters, even assisted by Revenue Officers. The public were roused to take an active interest in this serious situation when it became obvious that trade would be diverted to other ports if this state of affairs continued. Eventually in 1796 a Parliamentary Committee was " appointed to enquire into the best mode of providing sufficient accommodation for the increased trade and shipping in the port." The outcome of this investigation is now known.

Isle of Dogs Anniversary—continued

On the 8th August, 1799, the first statutory meeting took place at the London Tavern, the chairman of the meeting being Alderman Sir John William Anderson, Bart: This chairman is apparently no relation of the present well-known chairman, Lord Waverley, who before his elevation to the Peerage was Sir John Anderson. The new dock to be constructed would be completely isolated from its surroundings in order to athwart river thieves as well as providing a protection against fires. Vessels would not be allowed to navigate under sail in the basin, and no explosives or combustible materials would be allowed on wharves for more than 12 hours. The site of the Isle of Dogs two and a half miles downstream from London Bridge, was chosen because it was unoccupied land and could be obtained cheaply. It also required a minimum amount of excavation. The tongue shaped site, surrounded by the Thames on three sides, was ideal for providing two entrances — one in Blackwell Reach and the other in Limehouse Reach. The foundation stone was laid on 12th July, 1800, the procession of directors moving off from the London Tavern. A bottle containing coins — the former perhaps from the Tavern—were placed under the stone. The spot of this stone was positioned in No. 5 warehouse in the import dock. Two years later, on 22nd August, 1802, the West India Docks were officially opened by the then Prime Minister, Mr. Henry Addington. The first ship to sail into the basin was named after the Prime Minister. She was followed by the " Echo," which discharged hogsheads of sugar. Thus a new era of closed docks in the Port of London had commenced.

The opening on that historic day of these docks saw the first of the traffic docks on the Thames. The docks consisted of two parallel water areas with ample storage space in a number of five-storey warehouses. The docks were surrounded by 30-ft. high walls and a ditch 12-ft. wide and 6-ft. deep. This was a scheme to overcome the ravages of cargoes stowed there. There were several restrictions exacted on the new company, including that no structures should be built within 100 yards of the surrounding walls. Also no slips, dry-docks, graving dock or buildings for repairing or building ships should be connected with the dock system. These restrictions were not removed until 75 years later, the arrangements then having caused many inconveniences. The Trinity House Brethren were responsible for selecting the dock masters.

The act which brought the West India Docks into being also provided for a canal to be constructed between the Limehouse Reach and Blackwall Reach, across the Isle of Dogs just south of the new dock system. This canal, named the City Canal, was opened on 9th December, 1805—the Battle of Trafalgar was still fresh in the minds of all British citizens. The first ship to be towed through was the 500 tons " Duchess of York." From the first it was a financial failure mainly because although it saved ships a possible two miles sailing distance, the two locks which had to be negotiated sealed its doom. The steamship did not make its first appearance on the Thames until ten years later. In 1829 this canal was sold to the adjacent West India Dock Company, who then connected it with their own dock system and transferred it into a timber dock. Years later, between 1866 and 1870 this canal dock was reconstructed and enlarged and named the South West India Dock.

Four years after the opening of the West India Docks, new docks were opened at Blackwall by the East India Dock Company in similar style to the West India Docks. All ships arriving from the Far East were required to discharge in these new docks. On 16th July, 1838, the West India and East India Dock Companies amalgamated in order to fight more effectively the competition of the more conveniently situated London and St. Katharine Docks.

Once these new docks had been in full operation their advantages were quickly appreciated and new docks were planned and built. These included the Millwall Dock which was situated just south of the City Canal on the Isle of Dogs. This dock was opened in 1868. The Junction Dock (in the West India Dock area) was constructed in 1864.

Meanwhile in 1855 another milestone in the progress of these docks was attained when the West and East India Dock Company agreed to subscribe to the Birmingham Junction Railway which led to the building of the railway sidings at the West India Docks. The basin used was originally built as a compensating reservoir; this basin, which later became the waterside depot of the North London Railway and later the L.M.S., is now the Poplar Dock.

The new company formed by the amalgamation of the London and St. Katharine Dock Companies on 1st July, 1864, decided to build the Royal Albert Dock. This new dock created a very close rival to the East and West India Docks organisation, so new plans were made to overcome this serious competition. Deciding that it was not practical to deepen and widen the already existing docks, it was resolved to build new docks in the marshes to the north of Gravesend Reach, at Tilbury. These docks were constructed at a cost of nearly £3,000,000 and were opened in 1886. The " Glenfruin " from China of McGregor Gow & Co.—now Glen Line, Ltd.—was the first ship to enter these docks on the opening day, 17th April. The depth of the Tilbury docks was fixed by the depth of the Suez Canal, then being built, as it was hoped that most ships using the docks would be coming from the Far East and Australasia. The chief incentive for establishing the Tilbury Docks 26 miles from London was that it was hoped shipowners would prefer to berth their ships near the established place of entry of ships at Gravesend, while also saving that arduous journey up the Thames. The opening of the Tilbury Docks brought to an end the era of private dock construction in London.

The building of the docks at Tilbury brought financial difficulties to the East and West India Dock Company. They were therefore driven to adopt a suitable working agreement with the London and St. Katharine Docks Company. This agreement was promoted as a Bill in Parliament in 1888, when a joint committee took over the management of all the relevant docks except the Surrey Commercial and the Millwall docks. Despite this amalgamation the financial state of this new company, known as the London and India Docks Company, remained unsteady and signs of further deterioration in 1900 became obvious. This condition came to the notice of the Government and a Royal Commission was quickly appointed, and which sat for two years. This resulted in several Bills being presented in Parliament, the outcome of which was the Port of London Act 1908, which subsequently became law. This Act established the Port of London Authority which held its first meeting at 109, Leadenhall Street, on 16th March, 1909, commencing its duties on 31st March in the same year.

The P.L.A. immediately set up a large programme of improvements in the river and at all the docks, including the West India Docks.

In 1929 the Millwall Docks were connected to the West India Docks by cutting channels through from the West India Import, Export and South West India Docks to the Inner Millwall Dock. This new combination now forms the India and Millwall Docks system of the Port of London Authority. At the same time a new entrance lock, 550-ft. long and 80-ft. wide, leading from Blackwall Reach to the South West India Dock was constructed, so that large vessels can now reach any part of the combined dock system.

Among other innovations in the West India Docks is the machinery for handling fresh fruits at Canary Wharf. This consists of a quay 618-ft. long, 35-ft. wide with a two-storey warehouse, together with loading platforms, balconies and other elaborate equipment.

During the late war the quays, warehouses and mechanical equipment suffered considerable damage. Already shed space covering an area of about 30,000 square feet has been reconstructed in the West India Docks while other improvements are gradually being carried out. One policy of the P.L.A. has been to keep, where possible, the character of the original docks; hence the West India Docks are still mainly interested in the West Indian trade. This is seen from the fact that the Harrison Line, the Fyffes Line and the Jamaica Bananas Producers S.S. Co., Ltd. are among the shipping lines which dock regularly at these quays.

So now the West India Docks enter their fourth half-century, after seeing many changes, including the birth and growth of steam and diesel vessels. Docks never reach maturity, for with the development of shipping, changes in the packing and carriage of cargoes, and the trend to mechanisation, docks must for ever keep pace with shipowners' and merchants' requirements.

Silt Control in Rivers and Basins

Details of New Pneumatic Apparatus

By A. H. LAURIE, M.A.
(Formerly Assistant Scientific Officer, Royal Research Ship *Discovery II*).

A method of controlling scour and silt-bearing capacity by adjusting the vertical distribution of salt and fresh water in tidal rivers and by prolonging the transport of sedimentary material in streams, tidal or otherwise, by means of compressed air, has recently been patented.

Readers will remember that a description of a patented pneumatic breakwater appeared in the May issue of this Journal, and the principles involved in that patent have now been broadly applied by the inventor to the control of scour and silt. The following abstract of the patent specification is therefore of considerable interest in view of the possible application of the scheme in a variety of situations and circumstances.

The Principle

Tidal Rivers. Where the flow of fresh water is large, the flood in certain cases tends to move upstream, bearing silt, beneath the less dense river water. On the ebb, the fresh water tends to run out first, and the salt water which is in contact with the bottom tends to follow at a lower velocity.

It follows that the " scouring potential " of the ebb is not as great either in force or duration as it would be if the water were homogeneous from top to bottom. There is therefore a tendency for more silt to be deposited on the flood than is removed by the ebb.

If, however, the stratification into fresh and salt layers is annulled and a degree of mixing achieved, during the flood, or ebb or both, there will result an increase in the duration and velocity of the ebb along the bottom. The silt-bearing capacity of the stream (varying as the sixth power of its velocity) and the scour (varying as the square) will both be increased. In short potential energy in the tidal volume will more nearly be applied where it is most useful, at the bottom, and will take away much of the silt which is normally removed by dredging.

The stratification in tidal rivers is to be regarded as an extra natural condition which can be exploited where it exists in the application of the principles described below.

River and Sea Inlets. Improvements in silt control can be secured in two ways. One is by using vertical currents generated by a method to be described to redistribute the sedimentary material throughout the depth, thus relieving the lower levels, albeit temporarily, of their burden and prolonging the transport of material on the ebb. This applies particularly to channels in which there is a long period of flow at or near the critical velocity. In effect the silt bearing capacity of the channel as a whole is increased. The material is carried downstream a distance depending on its nature and density in relation to the hydrological status; a series of lifts in tandem will be required, operating during the appropriate period of the ebb.

The second method concerns the adjustment of the bottom to suit local requirements. If it is desired to concentrate on maintenance of a deep channel in the middle, the apparatus is arranged so as to create vertical currents which obstruct the spiral motion of the ebb. The spiral motion causes dissipation of energy by friction at the sloping sides and banks. By inhibiting this motion the speed of the current in the centre is increased, and with it the silt carrying capacity. The dissipation of silt from centre to sides which normally occurs will be checked. Fig. 1 shows an arrangement in a straight channel.

If an increase of depth is sought at the side, to improve berthing conditions, the apparatus is located near the quay (Fig. 2) in such a position that it induces an acceleration of bottom water at the point where its velocity is diminished by friction. Deposition of silt is postponed by the operation of the sixth-power law and the water and silt are raised to the surface and discharged towards the middle of the stream.

Tidal Basins. In certain basins there is an intake, on the flood, of silt-laden water at the bottom, with a corresponding outflow of water at the surface. The volume of water passing through the entrance is in excess of the tidal volume, and because the intake is at the bottom siltation is excessive.

In such cases the apparatus is used to create a countercurrent at the surface in order to inhibit the outflow. The countercurrent is produced across part or all of the entrance according to the location of the outflow. Model experiments suggest that the effectiveness of such an arrangement is greatly increased by placing a low baffle outside the pipeline so that the vertical current is composed principally of water already in the basin, without admixture of silt-laden water from the outside (Fig. 3).

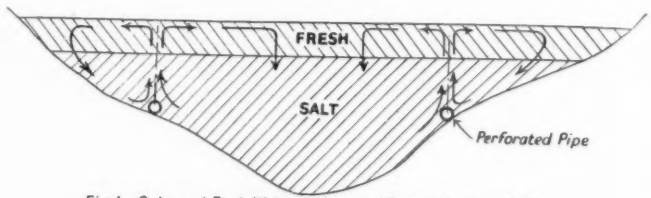


Fig. 1 - Salt and Fresh Water mixing and Redistribution of Silt.

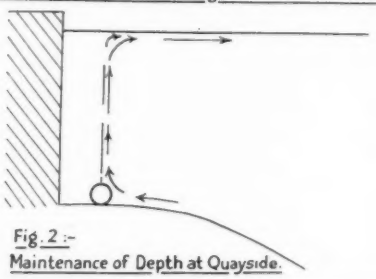


Fig. 2 :-
Maintenance of Depth at Quayside.

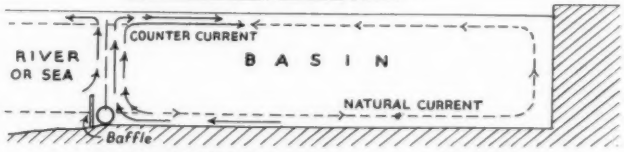


Fig. 3 :- Silt Control by Counter Current in Tidal Basin.

The effect aimed at is, in short, that of nullifying the natural eddy in the basin by the application of an equal and opposite force. Model experiments indicate that the power required is a minute fraction of that now being expended in dredging such basins.

The Method and Apparatus

Mixing of fresh and salt water and/or redistribution of sedimentary material are both procured by the same apparatus. A series of perforated pipes are laid on the river bed and connected to a source of compressed air. The emergent bubbles raise the bottom water and sedimentary material partly by their own upward motion through the water and partly by creating an air lift. Normally the pipes are laid longitudinally in the river bed following the bottom contour so as to secure equal hydrostatic pressure throughout. The working air pressure is arranged to exceed the hydrostatic pressure by a small amount and will, in tidal streams, vary with the state of the tide. Provision is made to prevent silt and other impurities from blocking the perforations, by the use of non return valves or by arranging to fill the pipe with clean water when the compressor is idle.

It should be emphasised that if an installation is properly matched to the problem the control of silt can be adjusted within fine limits by varying the period of operation. The power requirements are minute in proportion to the material and water under control and the system can be said to resemble a sort of hydraulic ju-jitsu in which a small force properly applied can divert much larger forces towards the desired end.

Hydrographic Sounding and Surveying

A Description of the Methods used in the Port of Dublin*

By WILLIAM F. STAVELEY, A.M.Inst.C.E. (Ireland).
Hydrographic Surveyor, Dublin Port and Docks Board.

(concluded from page 83)

Discussion

Mr. T. J. S. Mallagh (Member) said that he was very gratified to be asked to propose the vote of thanks to his old friend, Mr. Staveley, from whom he had learned almost all he knew about hydrographic work.

He knew that towards the end of the nineteen thirties the Port of Dublin's hydrographic work was second to none (with the possible exception of Southampton), and the same was true now. The major credit for this was due to Mr. Staveley, and with his paper he had rendered a great service to all engineers concerned with hydrography. Mr. Staveley's paper filled gaps left by the only existing text books on hydrography of which he knew, namely, the British Admiralty Hydrographic Handbook and Commander Macmillan's book referred to in the paper. Commander Macmillan's book emphasised double sextant fixing (the three point problem), and the preparation and the use of sextant graphs. He gathered from Mr. Staveley's paper that fixing by two sextant angles was not used for any of the Dublin Harbour surveys. He had an idea that when the old Sutcliffe machine was in use, fixing on the Bar was by two sextant angles. He had generally adopted the "three point problem" fix for hydrographic surveys, but after studying Mr. Staveley's paper, felt that on many occasions he could have, with advantage, used the single angle with transit fix. A less skilled observer was required for a transit, the probability of error was much less and the labour of preparing grid charts with one sextant angle was little more than half that required for the equivalent sextant graph. One of the difficulties he had found in preparing sextant graphs had been that, for any reasonable scale of final graph, the plot to take in the various sets of three points had to be of almost unmanageable size. He noticed on one of the charts in the paper that Two Rock Mountain and Ballycorus Chimney were mentioned, and, therefore, the same sort of difficulty must have arisen, although with two transit fixes the grid chart could be plotted to a small scale in the first instance and then easily enlarged

With one sextant angle, however, owing to one axis of the grid being curved, such a procedure would be difficult. Could Mr. Staveley say how the Bar Grid was prepared? Was it plotted to the final scale in the first instance, or was it enlarged; and, if so, what process of enlarging was adopted — photographic or otherwise?

Undoubtedly the topography of Dublin Bay was almost ideal from the hydrographer's point of view. The most difficult situation was when land rose steeply from a shore with few artificial features, but even in those circumstances many procedures described in the paper could be adopted with slight modification.

At Dublin Port the MS.10 Echo Sounder was used. He had experience of MS.12 in the tropics on two sides of the world. On each occasion he had asked for a MS.10, but because of what his superiors thought he was given the MS.12. Theoretically, the MS.12 might be a more suitable survey machine. It was more compact and more portable, but portability had been gained at the expense of accessibility, and when anything went wrong with the MS.12 almost complete disassembly was needed to get at the trouble. Furthermore, the MS.12 lacked some of the features of the MS.10, which were most useful for survey work—the timing dial and the artificial zero marker, for instance. In the MS.12 everything was worked off a 12-volt battery—the motor for the stylus drive, the rotary converter supplying high-tension current for both the oscillators and the amplifier, and the low-tension current for the amplifier valves. That resulted in a very heavy load for the ordinary 12-volt battery, and his experience was that unless the battery was absolutely full up, results were likely to be inaccurate and faint.

The MS.10 had a 36-volt battery. One of the worst troubles he had experienced with the MS.12 was rapid wear of the iridium tip to the stylus. This was during the war and may have been due to faulty material. Had Mr. Staveley experienced this trouble? Another trouble was keeping the front plate of the paper tank clean. How, and how often, had Mr. Staveley to clean that plate on his machine?

One final question: why 1½ tons of lead as a ballast keel for *Depthfinder*? With inside ballast, the metacentric height would be less, the motion much easier, and as long as the righting moment remained positive for all reasonable angles of heel—which could be made to depend on the body lines—the vessel would be quite safe. Possibly that may be a little outside Mr. Staveley's sphere, but he expected his friend, Mr. John B. Kearney, would answer this.

Mr. S. Mallin (Associate Member) said that the author had produced almost a text book on a branch of surveying that was not very widely known. Consequently, what he had written must be of considerable value to anyone concerned with hydrographic work. From time to time he had had to do such work, and would have to do it again. Hence he would stress his thanks to Mr. Staveley. Not being able to criticise and having very few questions to ask, he would like to describe briefly the background of surveying by echo-sounding methods. The first proposal to use sound waves was made at the beginning of the nineteenth century by Jean F. Arrago. There were various methods used for recording these waves and an advance was made at the beginning of the twentieth century, when a microphone was used for detecting them. The 1914-18 war gave an impetus to that method, but it was not until 1917, when, in France, a crystal method of generating the vibrations was developed that real progress was made. Later the method described by Mr. Staveley was developed in Great Britain. There were differences between the two methods and the signals used. The crystal method had a higher frequency and, therefore, presumably, a narrower beam. He thought the first general use of echo-sounding—apart from port surveying—in Britain began about 1924, and it had developed rapidly before the 1930's. The real snag, of course, was the problem of fixing. One thing made obvious by the paper was the necessity, in such a survey, of giving considerable thought to the manner in which the survey would be fixed before it was started. In the paper were implicit a number of suggestions for determining fixes. They would be of extraordinary value, not only for close survey work in a port, but also in less developed areas.

Another point to be borne in mind was the interpretation of the echo records. From personal experience he confirmed that Mr. Staveley was an expert in that.

Very dirty records could be produced due to oscillation, secondary echoes, noises of machinery, aeration of water under the hull, and so on, and it was not always easy to interpret the record. Another point was that the record could indicate whether the bottom was of mud or of hard material. Incidentally, he had seen recordings which showed depressions outside the line being sounded. His main interest in echo-sounding was concerned with fishing grounds and the location of fish. The general principles were the same. The only difference was that the sensitivity required was less than in port survey work, so that smaller and less expensive instruments could be used. A recently produced

*A Paper read before the Institution of Civil Engineers of Ireland on the 3rd December, 1951. Reproduced by kind permission.

Hydrographic Sounding and Surveying—continued

sounder used one oscillating tank instead of two. The transmitter and receiver were in the same metal box at the bottom of the vessel. There were one or two questions he would like to ask about the most suitable type of vessel to be used in more open sea conditions, paper was very complete and his presentation of it was a model. One was whether it would not be better to use a single-screw vessel, using perhaps, a variable pitch propeller, thus getting less aeration of the water. This should provide a much more sensitive control of the craft. Also, would it not be better to use internal ballast to the extent which internal ballast was necessary? The use of ballast represents a compromise. He did not wish to be too critical, but he thought that a slightly longer period of oscillation would be possible with internal ballast, and also, perhaps, greater comfort for the crew and surveyor in bad weather. Mr. Staveley's in itself.

Mr. D. P. Coyle (Associate Member) said that one point which Mr. Staveley had not covered was the limitations entailed in the use of the machine. On all the slides and photographs shown, the sea-bed was relatively flat and free from irregularities. Often the problem facing the civil engineer, as distinct from the marine engineer, concerned the construction of structures or the laying of pipelines on highly irregular sea-beds. On one occasion he had been associated with Mr. Staveley in surveying what appeared to be a rocky sea-bed in about 60-ft. of water. The survey resulted in failure owing to the fact that secondary effects predominated. Instead of getting a clear-cut record of the bed, the record was confused by secondary noises returned from fissures. This survey proposed to find out everything possible about the sea-bed and particularly the depth and extent of these fissures. Owing to the great width of the sound sent out by the machine, multiple reflections were received which were impossible to define on the records. Messrs. Kelvin and Hughes, the makers, thought they could produce a pencil beam which would penetrate fissures and give an accurate record, but to date they had not been able to produce such a beam. Up to the moment it did not appear to be possible to determine accurately a sea-bed with extreme irregularities, and the old method of using a plummet from the back of a boat still had to be used.

Mr. J. B. Kearney (Guest) said that it should be obvious that the outside keel that had been mentioned had been fitted to ensure that the launch would not go wrong side up and to prevent her from hogging should she strike heavy seas. The space inside the boat was fully occupied with various items, and there was lead ballast inside as well as outside the hull. The external keel was necessary, because there was not room within the boat for an internal keel. The stiffening effect of a lead keel also helped to prevent the propeller shafts going out of alignment. He felt that a variabile pitch propeller would cause more trouble than its advantages would warrant. Even in a pleasure launch he had known such a propeller to give trouble, and it usually ended with it being removed.

Twin engines reduced fuel expenses, because the launch would run very well on one engine when sounding. There was a reducing gear on both engines and the propellers were rotating in opposite directions. He wished to congratulate Mr. Staveley on a very interesting paper.

Mr. M. Maguire (Member) said that his first encounter in hydrographic study was many years ago—in New York. He was a young man at the time and was engaged in connection with the construction of a tunnel across New York Bay, at East River. The survey had to be carried out over the line on which the tunnel was being driven, and it was for the purpose of locating the position for a clay blanket to be laid across the one and a half miles stretch of river. Mr. Staveley's 1924 reference to surveying brought him back to the methods used in those days. All they were provided with were a row-boat and a lead line. They had two theodolite stations—one on an island and the other on shore. Powerful arc light sights were fixed on bridges and the boat was run at slack water between these sights. Soundings were taken continuously and the position of the boat was fixed from the theodolite stations. The soundings had to be taken during daylight and then rushed to the offices and prepared immediately so that the clay boats which travelled from New Jersey, would dump their loads on the tunnel line during the night. The work was very trying, especially in sub-zero weather, and often they worked amidst ice-floes. That was history, however, and he should now like to mention how interesting he had found Mr. Staveley's paper and how gratifying it was to know that this port of ours had kept so well abreast of modern developments in hydrographic survey methods.

He thanked Mr. Staveley for a very intelligent and very informative paper and he hoped young engineers would read and digest what he had so painstakingly prepared.

C. J. Buckley (Honorary Secretary) said that Mr. Staveley was an honoured colleague of his, and he could claim some little credit for the fact that the paper had been produced. The Institution was extremely lucky to have had a paper from Mr. Staveley, who was an acknowledged expert in these islands on hydrography. He had been of some assistance to Commander Macmillan at Southampton, and also to Messrs. Kelvin and Hughes, who made the echo sounder. His paper filled a number of gaps left by others who had written on the subject. There was remarkably little published information on hydrography and he felt that Mr. Staveley's paper would be of use, not only to engineers in Ireland, but also to hydrographers all over the world. Many of the methods which Mr. Staveley had designed were wholly his own; some were based on the work of others; but all were designed, not essentially to save himself trouble, but to make the best possible use of the conditions which allowed him to carry out his work, and his methods were in some cases quite ingenious. He himself did not claim to be an expert in hydrography survey; what he was concerned with were not Mr. Staveley's methods but his results in connection with the ordinary routine dredging of the Bar, the berths and the river and with dredging contracts, as well as foundations for deep water quays. The results that Mr. Staveley produced were always accurate and were produced to the same standard of excellence as was the paper he had submitted.

Mr. C. H. G. Crampton (Member) said that he should like Mr. Staveley say how often he had to repeat the survey, at what time it was necessary to get out the dredger, and how much must the sea-bed change before the use of the dredger was called for.

Mr. Staveley, replying, thanked the members for their reception of his paper and said that if he omitted to answer any of the questions asked he would reply to them in writing later. He said in answer to Mr. Mallagh that fixing on the Dublin Bar area was always done by transit and angle. What Mr. Mallagh probably had in mind was the survey of Rosbeg bank in 1936, which revealed an uncharted shoal and was the reason for the Rosbeg buoy having to be moved a mile or so to the south. Fixing on that survey was accomplished by two simultaneous sextant angles. This area is outside the limits of the port.

The Bar Grid, Mr. Staveley said, was drawn to the final scale of the chart. The distance between the two sextant stations, i.e. the common chord of the sextant arcs was calculated from a triangulation, using a measured base along the North Bull Wall. The arcs were drawn with beam compass. As the largest radius was about 45-in., the drawing space required was not too great. With regard to the back marks of the River Grid, i.e. Two Rock Mountain and Ballycorus Chimney, the same difficulty did not arise, as it was not always necessary to triangulate the back marks of simple transits. The transit lines were, of course, straight lines, and their direction on the chart was the only concern. This was determined by angle at the forward marks on the Gt. South Wall as in Chart A or by locating and identifying the intersections of the ranges with the far side of the Survey Area as in Chart B.

Mr. Mallagh was unlucky in having a 12-volt machine selected for him in the Tropics. MS.12 models are also made for 24-volt and 36-volt supply. Batteries in *Depthfinder* were kept fully up with the charging set installed on board. Mr. Staveley said he had no trouble with the stylus iridium points, but sometimes the stylus springs broke, but were replaced by the makers at small cost. The front plate should not clog up if the stylus spring pressure was properly adjusted, and should not require more than the normal attention. The most recent Survey model of the Echo Sounder was the MS.21, which had many refinements, probably based on the makers' contract survey experience. It was compact and portable and the adjustments were easy and accessible. Its

Hydrographic Sounding and Surveying—continued

small stylus radius, however, made reduction of soundings slightly more complicated than the MS.10 record using a straight scale. He was of the opinion that for a permanent hydrographic installation, the ideal machine would embody the long stylus radius of the MS.10 with the refinements of the MS.21. Mr. Mallin mentioned a narrower sounding beam. The MS 21 is fitted with smaller oscillators with a higher frequency than the MS.10. The makers say this gives a narrower beam. There was no reason to make a change on the *Depthfinder* installation, as the present type gave satisfaction. There was no difficulty with cross-noise, as the echo sounding machines are now fitted with a device called the " initial-suppressor," which eliminates cross-noise." No trouble was experienced with " aeration," which, he should explain, was water turbulence underneath the launch at the oscillator position. This occurred when the launch was going astern but not when it was moving forward, as the forward lines of the launch were very carefully designed to avoid this. Mr. Mallin had spoken about the open conditions in Dublin Bay and implied that it was necessary to survey in rough weather. He wished to assure Mr. Mallin that that was not the case. Accuracy is essential in these days of small margins of safety clearances. Sounding to the nearest three inches is essential and this would not be possible in rough weather. The *Depthfinder* was designed as a twin screw launch, as two medium-sized engines would give a sufficiently fast speed for getting to the survey area and a sufficiently slow speed for certain types of sounding, in particular the shipping berths. Also, cutting out one of the engines while surveying meant a saving of fuel. In practice, it had proved a great advantage to have two engines, as if one went out of action the launch made port on the other. On one occasion while awaiting delivery of a spare part for one engine, very good survey weather was utilised by being able to carry on with the other engine.

He agreed with Mr. Coyle that there were limitations to the use of the Echo Sounder. In the Survey over the irregular rocky bottom close to the Nose of Howth, referred to by Mr. Coyle, the confused record was caused by extraneous echoes which came from very steep side slopes. This was due to the fact that the Echo Sounder surveyed a path and not a line. Normally this was an advantage, because the appearance of a side echo often indicated the need for a more detailed examination of a survey area, but it had proved to have been a disadvantage in the problem with which Mr. Coyle was concerned. He understood that the makers were experimenting with a " pencil beam," but so far had not produced any result. The Survey he had carried out to try and assist Mr. Coyle had been of an exploratory nature, and while the rock fissures were not recorded, the tops of the rocky peaks showed up well and this would have been satisfactory from a navigational aspect. Strong tidal currents in this vicinity restricted the use of the lead-line to very short slack tide periods. The one day's echo survey, however, gave a lot of useful information. He felt that better results could have been achieved with a smaller scale echo sounder such as the 120-ft. scale MS.12, as phasing with the MS.10 could not be done quickly enough to record the sudden changes in depth.

He thanked Mr. J. B. Kearney, the designer of the launch, for answering the questions regarding the lead keel and the variable pitch propellors.

He was very interested in Mr. Maguire's description of the New York Bay Survey, and he appreciated his reference to the Port of Dublin being abreast of modern developments. This was due, undoubtedly, to the wisdom and foresight of the Dublin Port and Docks Board.

In reply to Mr. Crampton, he said that the practice in the Port of Dublin was to survey all the the areas as least annually. The dredging plant went into action in the spring following the winter lie-up for overhaul. It was essential that complete charts of the port were in readiness at that time for the Chief Engineer, as the complete dredging programme was arranged in advance. Contract dredging areas, shipping berths, foundation trenches, etc., needed a much greater frequency.

In conclusion, Mr. Staveley said that he felt privileged to be permitted to present his paper to the Institution and he was deeply grateful for the manner in which it was received.

Communication from **Commander D. H. Macmillan,** R.N.R. (Retd.),. A.I.N.A., F.R.I.C.S., Hydrographer, Southampton Harbour Board :

I consider the paper by Mr. Staveley on the above subject as a very useful contribution to the economics of harbour reconnaisance.

Whilst echo sounding, developed after World War I, provided the surveyor with means for obtaining abundant and immediate soundings at the speeds of up to 15-20 knots, the traditional methods for determining and recording the position of the survey vessel have hindered the exploitation of these great advantages.

This is quite a ridiculous situation, as simple means for immediate and accurate location of position whilst sounding should have at least kept pace with this new development.

Location by station pointer requires at least 40 second intervals between fixes for accurate work, and even this is somewhat of a " sweat " and leaves the surveyor absolutely no time for that deliberation required in the conning of his vessel and immediate consideration of soundings.

That the advantages of echo sounding should be so unnecessarily limited by such ancient techniques is absurd and unscientific.

Fortunately the development of location within a sound trigonometrical framework by means of intersecting lines *or* arcs of position has been successfully developed and when exploited to the full can give the surveyor complete and deliberate control of the entire plot at a reasonable speed for rapid examinations of under-water areas.

I have played some part in this development, but I think Mr. Staveley has shown great ingenuity in adopting various expedients to his important harbour area.

The use of the double optical square should be more widely appreciated, and I note that it has been extensively used by the Author in dock areas.

During the late war I was able to make a rapid examination of an important strategic area at a speed of 15 knots using the sextant graph technique.

It is, of course, possible under these circumstances to double up the observers and obtain alternative fixes at 15 second intervals, which would give accurate location at linear intervals of less than 400-ft.

I think Mr. Staveley has almost exhausted the very many devices which can be used to exploit echo sounding to the full in a harbour area requiring continuous re-survey under circumstances which put results beyond the area of controversy. I think the following three essentials definitely achieve this end :

(a) Accurate basic trig. for shore control.

(b) Carefully prepared charts giving lines of position by sextant arcs or transits.

(c) Careful bar-calibration and close watch on echo sounding gear for consistent speed throughout the survey.

The Author's appreciation of all these points, which I discussed with him many years ago, is obvious and very gratifying to one who has spent considerable time in working out such principles.

Shipping Turn-round at Australian Ports.

The Annual Report of the Australian Stevedoring Industry Board, which was recently presented to the Federal Parliament, states that more cargo passed over Australian wharves during 1950-51 than ever before, and that this satisfactory result was achieved in spite of industrial trouble, which was offset to some extent, however, by the greater use of the available manpower. Other factors which slowed down the work of the wharves were cargo congestion and union resistance to increase labour for various ports. The Board expressed the opinion that the rate of work is not the main factor in the turn-round of shipping, and in some cases, where wharves are congested, a complete stoppage can only be avoided by reducing the rate of work. The harmful effect congestion may have is illustrated by statistics of the Port of Sydney, which show that in 1950-51, 30.5% of employment time produced no movement of cargo, that is, almost one non-productive hour in every three hours of employment.

The British Transport Commission

Review of Fourth Annual Report

(Specially Contributed)

The appearance in mid-July of the Fourth Annual Report for 1951 has been somewhat overshadowed by the interest and confusion resulting from the presentation of the new Transport Bill to Parliament. The financial and statistical tables which have previously been included in the same volume as the Report, appeared this year a month beforehand at about the same time as the White Paper, which was a forerunner of the Bill. Commentators have, therefore, had the opportunity to express opinions about the operation of the British Transport System, before reading the views of those who have been running it.

In view of the translation of this vital industry into the political arena, it is difficult to study the wealth of factual data, and to consider this objectively, without becoming involved in the kind of political controversy which is of little interest to most readers of this Journal. Nevertheless, any student of transport economics will benefit from a study of these publications and the conclusions which may be drawn about transport operation and economics generally.

It is relatively unimportant whether the analysis of the results, and the opinions of the official authors, are acceptable to every reader; they are clearly and courageously expressed and recommendations for solving some of the inherent problems of such a unified transport system are still well worth study. The following paragraph from the letter written by the Chairman, Lord Hurcomb, to the Minister of Transport, which is, as usual, published as a foreword, is representative of the Commission's attitude : " In this fourth year, the Commission reached financial equilibrium in their undertaking as a whole and a small favourable balance is shown, after meeting all charges properly chargeable to revenue, interest on capital in full, and a charge of nearly £3m. for amortisation of capital. If the Commission were able to proceed with their plans for the integrated development of their services under a suitably revised organisation of their administration, and if they were permitted to adjust without undue delays the level of their charges to meet the costs of the various services provided, they would look forward with some confidence to the maintenance of the equilibrium achieved."

As the " Times " observed, " Such a report is rarely entirely impartial and this is no exception. It is, in part at least, an apology and defence. Perhaps, too, the fear of partial dissolution has added here and there a touch of acerbity."

The main task of the Commission has been the integration of British transport resources. Whether it could ever succeed with its present organisation, its statutory liabilities, its vulnerability to vociferent public pressure and with opposition from many of its employees, is open to question. Whether in achieving the elusive economies which should follow integration, the public will retain some freedom of choice, is even more doubtful, although in the Report, a powerful case is made to show that the customers' freedom will not be prejudiced. In the words of the Report:

" There is no question of withdrawing from customers the services they require and for which they are prepared to pay a reasonable price. The Commission have made no attempt, and do not intend to attempt, to enforce arbitrary selections of their services upon the public. There is no question, for example, of forcing the customer away from road or rail. Suggestions to the contrary are not justified. All the Commission ask is that the customer shall pay the real cost of the services he selects, and that he shall not receive one service at its bare cost if he insists at the same time on the maintenance of other services at less than cost. Though in the present state of the country's financial and economic position it is difficult to establish what the true long-term costs of different forms of transport will be, it is of vital importance ultimately that the true costs of the various services shall be brought home to the customer. This will never be achieved by partial competition between services with different public obligations and with charges fixed on different principles. Only when co-ordinated charging arrangements for both rail and road are in operation can the true costs be made to ' compete ' with each other, and thus bring into proper play those forces which will influence the customers as a whole to make use in the most economic ways of the services they desire."

Such passages as the above and the appendix, " Some notes on Traffic Costing," are typical of the contribution which the Report makes to an understanding of transport economics. In previous years, the comments in these columns have included appreciation of the unenviable position of the Commission in attempting to tackle some of the problems at their roots. It is unfortunate that the present state of uncertainty is not likely to promote progress and further achievement.

Improved Consolidated Results.

For the first time, there is no longer a deficit on the year's working, although a deficit of nearly £40,000,000 has to be carried forward from previous years. The elimination of losses on a year's working might be taken as indicative of substantial progress, despite the economic difficulties of the times. However, the Commission is courageous and honest enough to observe that " the apparent discrepancy " (i.e. between increases in costs and the somewhat lower increases in charges) " is partly explained by a reduction in the relative burden of capital charges. A further ' saving ' is accounted for by the fact that the depreciation charge is based mainly on historical cost instead of on present-day replacement costs . . . . . In any case the amounts to be provided for depreciation are rising slowly as the old assets are worn out and new ones have to be bought to replace them. Only the reduction in the true charge for interest on capital is permanent." However, these considerations have applied equally in previous years and the present results undoubtedly represent some improvement. It is ironic that at the very moment when the Government should be proposing the dispersal of the Road Haulage Service, the Commission is able to claim " noteworthy improvements in the operation of this with a surplus of £3,250,000 compared with a loss of £1,100,000.

The problems arising and the decisions on future policy must be considered in an atmosphere of sanity and reality, and it would be deplorable if political prejudice carried more weight than hard economic facts. It is satisfactory to observe that since the publication of the White Paper, responsible commentators have repeatedly stressed the fact that the question of *ownership* of any part of the system does not necessarily have any bearing on *efficiency*. The problems underlying the system are technical and economic and remain the same whatever the ownership. To take an example of particular interest to the readers of this Journal and which has been given prominence in its columns, the proper policy in relation to a canal with little traffic potential is the same however it may be owned. The questions are, what are the conditions which are most likely to lead to the right decisions, and what are the conditions which are most likely to promote vigorous action? With this example in mind as being typical of the kind of problem facing those responsible for a transport system, it should be remembered that, before the 1947 Transport Act, many such canals (carrying little or no traffic and unsuitable for enlargement to economic gauge) were kept at least nominally navigable by their Railway proprietors, and the losses, which were mainly the result of a deliberate policy to direct the traffic to the railways, and hence eliminate competition, were met out of railway profits. A century of Railway ownership of an important minority of canals has had an effect, little short of disastrous, on the development of an efficient inland waterway system. Since nationalisation and unification the extent of these losses have received much publicity and so become more obvious, but they are still being met out of the surplus on other operations. Perhaps, such a waterway may fulfil other functions than the carriage of goods commercially, and in that event it is right that it should be maintained for water supply, drainage, pleasure, amenity or historical interest, but the cost of its maintenance should not be a burden on the remainder of the transport system. The point which must constantly be borne in mind is that the right decisions must be taken on such matters as these, and when the matter of ownership is under consideration, the policy should be to create conditions conducive to sane decisions and enterprising management, rather than one which merely makes the situation more obscure. Here the Commission has released some figures to show that the deficit on canal operation (£186,000) would have been

British Transport Commission—continued

turned into a surplus of £175,000, if canals which carry virtually no traffic, and the Caledonian and Crinan Canals, had not been a burden to the transport system.

Port Operation.

The section of the Report referring to port operation and dock ownership contains some evidence of progress. Final results show a large improvement upon those of 1950 and earlier years and for the first time, show a surplus:

	1948 £	1949 £	1950 £	1951 £
Gross receipts ...	10,799,704	11,717,946	12,497,706	14,867,486
Working expenses ...	12,129,188	12,541,999	12,552,553	14,050,245
Deficit	1,329,484	824,053	54,847	—
Surplus	—	—	—	817,241

Most of the major ports of Great Britain remain independent, and although some have been the subject of a report by the Docks and Inland Waterways Executive, no decision had been announced following the Review of Trade Harbours (under Section 66 of the 1947 Act) until the recent Transport Bill, under which Section 66 is due for repeal.

Canal Ownership and Carrying.

As mentioned above, there is again a deficit on canal operation, due, as has been repeatedly emphasised, to the many miles of little used waterways and also to the Caledonian and Crinan Canals, the cost of which was transferred from the Exchequer. The publication of the following figures referred to above make the position clearer.

	Surplus £	Deficit £
(a) Waterways which carry substantial traffic and would appear to offer scope for commercial development	255,000	
(b) Scottish Canals taken over to the relief of Exchequer (Caledonian and Crinan)		46,000
(c) Canals which, though not profitable, appear to merit retention for transport purposes ...		80,000
(d) Canals which carry virtually no traffic or are already closed to traffic		315,000
	£255,000	£441,000
Net Deficit		£186,000

Guided by the general belief that inland water transport is economically best suited to bulk movement to and from the ports and for certain other traffics, the Commission lay down as their policy a proposal that certain waterways already carrying substantial traffic, offer scope for further development, viz. : Aire and Calder, Sheffield and South Yorkshire, River Trent, River Weaver, River Severn and Gloucester and Berkeley Ship Canal, River Lee (Bow Locks to Enfield), and Grand Union (Regent's Canal Dock and Brentford to Berkhamsted).

In addition, the following waterways are recommended for retention even though some of them have limited capacity; viz.: Calder and Hebble, Leeds and Liverpool, Shropshire Union (Main Line), Trent and Mersey, Birmingham Canals and certain connecting waterways, Coventry Canal, Grand Union (above Berkhamsted) and Oxford Canal (Northern Section).

The canals which fall into these two categories, taken together, are presumably those which show the surplus of £175,000 mentioned above.

Here, it seems appropriate to quote some figures which emphasise the fundamental reasons for uneconomic operation of English canals, compared with those on the Continent; the low average density of traffic arises from the mileage upon which there is little traffic and the small capacity of the boats.

Comparison with European Waterways.

	Traffic in ton-km. per km. of waterway	Inc. over 1949
Belgium	1.7 million	14.0%
France	.5 million	7.6%
W. Germany ...	4.8 million	34.0%
Netherlands	1.4 million	23.0%
U.K.	.088 million	1.6%

(United Nations Economic Commission for Europe, Transport Returns 1950)

The large increases in traffic on the Continent speak for themselves. They are less marked in France, where " the industry is suffering from the disadvantage of small capacity compared with her neighbours—280-350 ton barges compared with 600-1,000 tons, or more." (M. Peltier, Cong. Int. Transp. Fluv. 1947.) Nevertheless canal traffic in France in 1949 amounted to 15 per cent. of *all* rail freight traffic (34 per cent. in 1938), while it is less than 1 per cent. in the United Kingdom.

The dimensions of the major French canals, which M. Peltier regards as inadequate for efficient working are 125-ft. x 16-ft. x 6-ft. draught, but these are capable of passing boats with ten times the capacity of the English narrow boat.

It is reported that the Docks and Inland Waterways Executive have been asked " to give close consideration to the abandonment or transfer of certain sections of canal which no longer fulfil any useful or economic transport function, though in some cases serving the interest of drainage, industrial water supplies, or local amenity. Serious obligations were placed upon the owners of canals when their construction was first authorised by Parliament or have become attached to them during their long existence. Negotiations are proceeding with several local authorities and other bodies with a view to obtaining satisfactory terms of transfer of certain lengths of disused canals in their areas, but in the Commission's view the whole problem of the unused or little used canals merits special consideration with the aim to transfer from the Commission, whose purposes they no longer serve, to bodies who are closely concerned in their continued existence for drainage, water supplies, or recreational and amenity uses as the case may be."

Little seems to have been achieved during the year in the way of transferring these waterways, and this is clearly a matter for action by the Government, for it is most unreasonable that the Commission should be blamed for uneconomic results when faced with this major problem of redundant assets.

The Executive's carrying activities also show a loss on the year's operation and there seems to be no other explanation for this, except that the Executive's fleet contains many uneconomic narrow boats; barges of economic dimensions are quite widely used on many of the Commission's waterways under private management, but the favourable results of operating the latter are not covered in the Commission's Report. Furthermore, the working conditions on long-distance narrow boats are known to be barely tolerable by present-day standards, and this is another reason for an early decision upon the future of English waterways.

G.L.H.B.

Construction of Large Oil Tankers

Orders Placed with British Firms

It is reported that orders for the construction of seven tankers, each of about 32,000 tons deadweight, have been placed by the British Tanker Co., Ltd., shipping subsidiary of the Anglo-Iranian Oil Co., Ltd. Contracts to the estimated value of over £12 million, have been placed with five British Shipbuilding firms and the work is now in hand.

The British Tanker Company already has 21 tankers, including six of 32,000 tons deadweight, under construction or on order, while the tanker fleet in service totals 155 ships.

The hulls of the new vessels will be similar in design to the 32,000-ton ships already on order, but the machinery installation, will be somewhat more powerful, giving an average speed of 15½ knots in service with full cargo. The principal dimensions will be: Length 675-ft., beam 86-ft., with a summer draught of 35-ft.

The company state that although the size of the proposed tankers will limit the number of ports where they can operate, it is estimated that these seven ships will be capable of providing a greater service than 23 of the 12,000-ton vessels, which were the largest type operated by the company before September, 1939.

Mechanical Aids to Speed Ship Turn Round

Demonstration at the Port of Sunderland

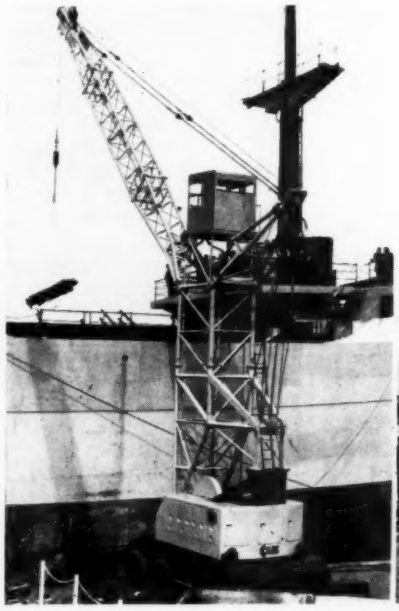
A demonstration of modern cargo handling devices was given recently at the Port of Sunderland before a gathering of experts representing Port Authorities, Consulting Engineers, Stevedores, Shipping Companies and others connected with the port industry. The trials were arranged by Steels Engineering Products Ltd., Crown Works, Sunderland, makers of Coles Cranes and other mobile handling plant, and those attending the demonstration were particularly interested in a new Coles crane of revolutionary design which may well be the answer to many problems concerning the modernisation of cargo handling methods and the faster turnround of shipping.

The site selected for the trials was unusually difficult for crane operation and was, therefore, of particular value to show what the crane could do in working a ship's hold in circumstances more difficult than is usually found in the United Kingdom, though sometimes encountered overseas. The manufacturers believe that the new crane is not competitive with existing types of quay cranes but is complementary to them. They do not claim that its introduction will solve all the problems of the fast and economic loading and discharge of ships, but believe that it has a contribution to make to their solution.

The particular interest in the crane lies in the fact that it effectively combines the advantages of the mobility, flexibility and manœuvrability of the pneumatic-tyred mobile crane with the long outreach, considerable height, and visibility of the operator essential for working the holds of ocean-going ships. The high cost of installing new, or replacing obsolete, permanent cargo-handling plant tied up on one quay, which is so necessary for the rapid turnround of shipping, cannot always be justified by the volume of cargo which it is called upon to handle at that particular quay. In some ports, therefore, the replacement or extension of rail-quay cranes cannot be justified on economic grounds since they must inevitably stand idle for a large percentage of their time. The special interest of the present machine therefore lies in the ability of the port manager to concentrate cranage at any particular berth as required, and to disperse cranage at other times at various berths or in re-handling and stacking sites throughout the port area.

The new crane is electrically operated but generates its own power by means of a diesel or petrol engine which makes it independent of trailing cables and power points, just as it is also independent of rail tracks. The crane has four motions, each powered by individual electric motor—hoist, derrick, slew and travel. The Coles Variable Voltage System provides simple control of all operations, more than one of which can be carried on simultaneously, and gives a very exact and delicate control of loads.

The crane travels on six large pneumatic-tyred road wheels which evenly spread the weight over a large area, effectively preventing any damage to the surface of the wharf-apron or to roadways. When handling loads, a fixed base is provided by the extension of telescopic girder stabilisers. The crane will lift 3 tons at 30-ft. radius to a height of 63-ft. above quay level and from a depth 50-ft. below quay level. It will handle 2 tons at 40-ft. radius to a height of 55-ft. above quay level from a depth of 58-ft. below quay level or 1½ tons at 50-ft. radius to a height of 40-ft. above quay level from a depth of 73-ft. below quay level. These duties are adequate for general cargo and the holds of medium-sized ocean-going vessels. Hoist speeds will be available up to 150-ft. per minute with 1½ tons on the hook and free barrels will be available for gravity lowering when required. Travel speed is up to 4 miles per hour.



Left: The new mobile crane handling 1½ long tons of steel tubes from hold of ship. (Working at 50-ft. radius, giving a height of lift from apron level of 40-ft. and clearing a free-board of 28-ft.) Right: Visitors watching a demonstration of the crane travelling with mast lowered.

When operating the crane, the driver is seated 36 feet above quay level and is thus provided with a clear view of the deck and the farther side of the hatch. The crane can move under its own power from one berth to another and from one quay to another with the tower erected, and when it is required to travel considerable distances or to pass under obstructions, the tower can be lowered so that the clearance height is only 17-ft. 9-in. The crane can both lower and erect its own tower, so that it is capable of travelling some distance to a new operational site and of erecting its tower to be ready for further duties without any assistance from other plant. It is full circle slewing in either direction without limit and the 50-ft. jib which is of strong tubular construction, can be derricked from maximum to minimum radius in 10 seconds. Many safety devices are incorporated, including automatic limit switches to prevent derricking the jib beyond the prescribed limits, automatic hoist and lowering limit switches, automatic safe-load indicator, automatic electro-magnetic brakes, and automatic reversing steering which enables normal steering to be effected by the driver whether the jib is towards the front or the rear of the chassis during travel. Road wheel brakes are power-assisted and the crane is equipped with electric lighting and electric starting.

Another machine demonstrated was the Coles S.810 Mobile Crane specially adapted for cargo handling. This machine, which is diesel/electric or petrol/electric, is self-propelled on pneumatic tyres and will lift and carry loads up to 6 tons. For port working it is capable of moving heavy loads from the wharf-apron to the transit shed or re-handling area, or on to road and rail transport.

Two Electric Eel Industrial Tractors, also manufactured by Steels Engineering Products., demonstrated the modern method of moving goods quickly from the wharf-apron to the transit sheds in order to maintain a constant flow from the ship's hold to prevent congestion. The smaller tractor has a drawbar pull of 1,200 lbs. and the larger a drawbar pull of 4,000 lbs., the latter being mounted on pneumatic tyres. Both these machines are powered by electric batteries and are therefore suitable for entering transit sheds without danger of fire risk or contamination of cargo.

Another interesting item was the Electric Eel Loadcarrier which has a large platform 8-ft. x 3-ft. 6-in. and an offset control column to facilitate the transport of long loads such as sawn timber or steel sections.

The trial and demonstration was followed in the afternoon by a discussion, during the course of which many practical comments and suggestions were put forward with a view to improving cargo handling efficiency at ports

Oil Pollution of Seawater

Since the publication in the June 1951 issue of this journal of an article surveying past and present investigations, legislation and international action on the subject of oil pollution of seawater, some further developments have occurred. Firstly a considerable amount of public interest has been created due, no doubt, to the advent of the holiday season, whereby visual evidence has been received by large numbers of people, of the deleterious efforts of oil which drifts on to the beaches of British holiday resorts.

Prosecutions of certains offending vessels and refineries have been made and as a result of action taken by the Association of Municipal Corporations and others, questions have been asked in the British House of Commons as to whether the Minister of Transport, had now concluded his review of the problem of the pollution of the sea and of beaches by oil, and what action he proposed to take in the matter.

It will be remembered that the subject of oil pollution of seawater has engaged the attention of UNESCO, and that the Secretary of the United Nations approached the British Government towards the end of 1950, with the result that some preliminary views upon certain points have already been passed to the United Nations Organisation, also that the Ministry of Transport instituted a comprehensive preliminary investigation, a questionnaire having been circulated to shipowners, port authorities and other interested bodies.

The results and opinions arrived at, have, so far, not been made public, but on the 22nd July last, the Minister of Transport announced that it had been decided to appoint a committee from the Government departments concerned and other interests, to consider what practical measures could be taken to prevent oil pollution of waters round the coasts of Britain. He also stated that he was arranging for surveyors of his department to go on board oil tankers in the main tanker repair ports, and examine the measures adopted to prevent the escape of oil. This would include ascertaining where tank washings and ballast water were discharged.

In this respect the Oil in Navigable Waters Act, 1922, gives harbour authorities the power to designate places at which tank washings from petroleum spirit cargoes, which rapidly and completely evaporate, may be discharged within harbour limits. Similarly harbour and port authorities have the obligation of providing receptacles for the disposal of any type of waste oil, while ships are in port, at prices, which in accordance with agreement come to with the shipowners, will " cover expenses and leave some reasonable remuneration on the outlay." There, is, however, no evidence at present whether such facilities as have been provided are fully utilised or, on the other hand, whether they are adequate in number and capacity, in view of the large increase in shipments of crude oils.

The Minister of Transport further added, in his recent statement, that three British tanker companies had decided to carry out investigations at their own expense to ascertain the drift of oil when discharged at sea, and that his department had arranged for representatives of the appropriate Government departments to take part. The investigations will be carried out by an observation vessel, on board which will be oil and shipping experts and scientists who will follow the drift of both crude oil and fuel oil discharged into the sea as part of normal tank-cleaning operations at distances exceeding 50 miles from the coast, to determine the rate and direction of flow and take samples at intervals for analysis to determine the consistency of the oil, whether it coagulates, breaks up or sinks and, in fact, what happens to the oil from the time it is discharged into the sea. It is expected that the whole experiment, will take about two months to complete.

It will be recalled that the first steps to deal with oil pollution in this or any other country were taken in 1922 by Great Britain, when the Oil in Navigable Waters Act was passed. Subsequently, in 1926, a Conference in Washington drew up a draft Convention providing for the establishment of zones extending up to 50 miles and, in exceptional circumstances 150 miles, from the coast, within which the discharge of oil was to be prohibited. This Convention has never been ratified by the Governments concerned, but British shipowners (and shipowners of other countries) of their own accord, instructed their ship masters not to discharge oil or oily waste within 50 miles or any coast. This rule is incorporated in standing instructions to ship masters, who are presumably well aware of the importance of its observance. It is apparent therefore that for many years British shipowners have not only recognised the serious consequences that follow pollution but have recommended and voluntarily adopted for general use what were considered to be effective measures to combat the evil.

Since the war, however, developments have drastically and probably permanently changed the pattern of the oil trade and that change may have contributed to the undoubted increase of oil pollution of our coasts. Some five or six years ago, the majority of oil imports consisted of oil which had already been refined. Today the great expansion of refining in the United Kingdom and Continental ports means the importation of crude oil on a large scale. In 1938 under one-fifth of the petroleum oils imported into the United Kingdom was crude oil. In 1949 the proportion was one-third and now it is nearly two-thirds. Between 1938 and 1951 the total imports of all kinds of petroleum oils have more than doubled. Today about six times the pre-war quantity of crude oil is being imported into this country alone and the import of crude oil to Continental refineries has also increased.

Certain refined oils present no problems; for example petroleum spirit cargoes, which rapidly evaporate, and may therefore be discharged within harbour limits, under certain conditions. In contrast, pollution by fuel oil can have serious effects, particularly on animal and bird life. Fuel oil is an expensive commodity—it costs about £9 a ton and a modern ship may use up to 50 tons a day or more—so that apart from any other consideration, it is never wilfully wasted. The growing practice of British shipowners nowadays is to fit separators in passenger and dry cargo ships, in order that fuel oil from bilge and ballast water may be recovered and, if of suitable grade, consumed as fuel. There are, however, certain classes of vessels, notably tankers, where the fitting of separators appears to offer no solution.

For example, when a 15,000 ton cargo tanker carrying crude oil has discharged its oil, there may remain in its tanks some 25 tons of " sludge "—a heavy, viscous, waxy substance—too solid to be pumped out but which must be removed before a ship can be repaired. It has a low flash point and its use as fuel in ships is out of the question.

A separator on board is no use in the removal of sludge. After a cargo of crude oil has been discharged, even if the tank drainings have been passed through a separator, the sludge remains and has to be disposed of in some other way—either to a shore receiving station or overboard while far out at sea. It is stated that British Shipowners are already using to the fullest extent the existing shore facilities, the provision of which is at present being increased.

Though much is known on certain aspects of oil pollution, there are still large gaps in knowledge of the behaviour and capacity to persist, under various weather conditions, of oil deposited at sea. It is the object of the two months' experiment. referred to above, to gain more knowledge on these matters. It may yet be proved, for example, that oil discharged some hundreds of miles away from Britain can be a cause of the soiling of British beaches, or, that oil put into the sea just outside the 50 miles radius will, in that distance, disperse and become harmless before reaching land. Thus the data collected from the experiment outlined should prove of great value in getting to grips with the latest manifestations of oil pollution.

There are no immediaite ways of guaranteeing a cure. A law by this country forbidding the discharge of oil at sea anywhere could apply to our own nationals only, and to foreigners within United Kingdom territorial limits. It could not apply to the large volume of foreign shipping passing our coasts bound to and from North European ports. International agreement would, therefore, be required for the adoption of any further measures found to be necessary or desirable. The International Chamber of Shipping is being kept advised of the action now being taken by British Shipping in order that foreign shipowners also may have the advantage of the experience which it is hoped to gain.

Sea Transport of Iron Ore

Productivity Report on Iron and Steel Trades

The British Iron and Steel Productivity Team which recently visited heavy steel works in the United States, under the leadership of Sir Charles Goodeal, published its Report at the end of June last. The tour of inspection lasted five-and-a-half months and was undertaken during 1951 under the auspices of the Anglo-American Council on Productivity, and the E.C.A. technical assistance programme.

As is to be expected, the report contains much information of value to those directly concerned with the steel industry, but the section on water transport of ore is also of interest to all dock and harbour authorities who are connected with the export or importation of iron ore.

The object of the tour of inspection was to study American steel production methods with a view to ascertaining what aspects of American procedure, practice and policy might be adopted with benefit to the British steel industry.

Broadly, the finding of the team was that whereas British steel was the cheapest of all countries, except Australia, it could only be kept so by continuous modernisation and the most effective utilisation of plant. Moreover, in all sections of the British iron and steel industry the greatest limitation upon productivity to-day is the size of the unit of plant. In this connection, the American industry possessed many advantages, for example " the higher productivity of both plant and labour in the American heavy steel industry may be attributed mainly to larger units of plant in larger works, the greater purity and abundance of raw materials, faster driving of plant and the use of high-grade fuel, including oil and natural gas."

" Cheap transport is essential to the concentration and flexibilty of the iron and steel industry. For instance iron production from low-grade home ore is greatly improved when this is blended with high-grade imported ore, and a reduction in the cost of transport would make economically feasible the use of a proportion of foreign ore in almost every blast furnace in this country. Also, home ores could be used more economically over a wider area. In fact, cheap transport of raw materials and products would materially affect the whole economics of steelworks' location and size. It would also improve competition between works and specialisation in products."

After comparing American steelworks' practice with that of Britain, and also the form, capacity and design of plants, the availability and use of high-grade ores and fuels, research, and the financial aspects of the industry in the two countries, the team makes recommendations upon many of these features with which readers of this journal are not specially concerned. In respect to sea transport, however, and the handling of ore in large quantities, it is observed that, " in most cases the conditions applying in America are not comparable with those in Britain, since the bulk of the ore consumed comes via the Great Lakes and is handled by regular large-scale shipments between the same ports and over the same routes. Winter freezing of the upper lakes, interrupts this steady stream of traffic, so that considerable stockyard capacity at the steelworks is necessary. The specialised nature of this traffic permits the standardisation and use of large-capacity steamers and handling machinery.

" Ore supplies to Britain come by sea from a great number of diverse foreign ports of different size and capacity. In fact, ore is at present imported into Britain from some 15 countries in at least 35 different grades and from about 70 different mines.

" Seaborne ore to America is a small proportion of the total used. It is mainly taken up by a few large companies, and comes from about six countries, each sending only one grade. Most of it is transported in large-capacity vessels specially designed for the purpose. It is unloaded mainly at Baltimore and Philadelphia where, as on the Great Lakes, there is virtually no tide, the rise and fall at these ports being only about 3-ft. This eliminates the necessity for enclosed docks with, as in some British ports, consequent restrictions on entrance gates and sills which limit the size of ship which can be accommodated.

" The most recently-built independent unloading facilities for general ore traffic at Baltimore have a capacity for discharging 1,500 tons per hour by two tower unloaders operating directly on to a belt. At one lakeside works, fast unloading equipment working from modern high-capacity steamers can attain the high rate of 2,500 tons per hour.

" The American industry also has an advantage over the British in being able to control either directly or indirectly its own fleet of ore carriers. In Britain the availability of ore ships has recently become a serious problem, and a start towards greater control has been made by building special vessels to be operated for the industry. It would seem desirable that this policy should be continued and expanded to meet long-term needs; 10 years hence the size of works and the demand for imported ore will have increased considerably."

The ships under construction at present are of 8,500 tons in order to serve certain ports where drafts are restricted. Seven ore carriers have been ordered each having a d/w of 12,000 to 14,000 tons, and ships of 14,000 to 15,000 tons' capacity are planned, and even larger ships are under consideration. While is is not possible or perhaps desirable to attain equality of size with American ore-carriers, it is noted that the latest sea-going vessels now being built (in Britain, incidentally) for the American industry will have a cargo capacity of 22,500 tons. However, there is considerable scope in Britain for greater economy and efficiency as regards the transportation from overseas, and the handling in our ports, of imported iron ore, and it is encouraging to learn not only that the industry is aware of the future needs but that it is planning vigorously to meet them.

In the final summing up of the general position of the industry, the report states that " Many big handicaps will always remain. Britain will have to rely to a great extent on home ores which are inferior in quality to American ores. She will for some time at least be left in doubt as to whether her plentiful coking coal can be got out of the ground fast enough to meet the growing needs of her furnaces. She has a heavy investment in a large number of steelworks, each of which contains some valuable equipment not to be scrapped without hesitation; yet the layout and balance of these works limits the size and character of new units.

"Once a country has attained a high productivity she at the same time achieves surplus resources which she can readily supply to further re-equipment so as to attain a still higher productivity. The U.S. is in that position to-day even with her demands for rearmament, but Britain is far from it.

"Against all this, the advantages can be summed up. British steel-makers have a technical knowledge of their craft second to none in the world. Their home ore, while poor in quality, is very cheap to mine. Most world developments in mining ore must be taken by sea, and the British steel industry is very favourably placed to receive seaborne ores and convert them to iron and steel.

" In addition, there is a large potential market for steel and steel products wherever ships may go, although competition may become much keener. Associated with the internal and external markets are, respectively, the short internal rail and road hauls and the large and efficient merchant navy."

Copies of the report may be obtained from the Anglo-American Council on Productivity at 21, Tothill Street, London, S.W.1, or from the British Iron and Steel Federation, 11, Tothill Street, London, S.W.1. (Price 5s. post free.)

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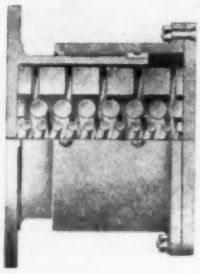

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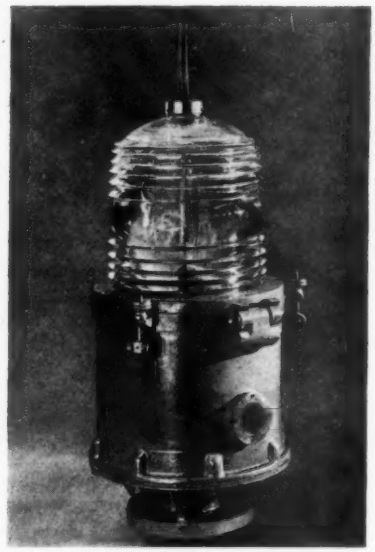

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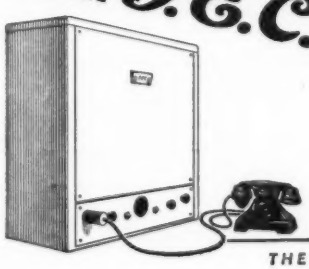

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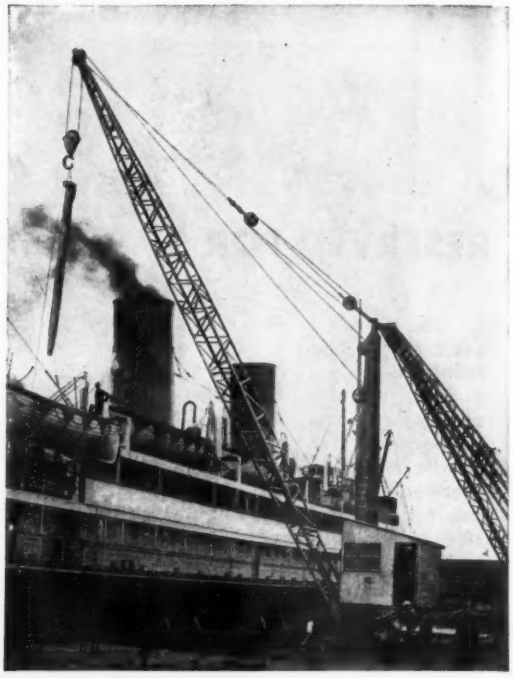

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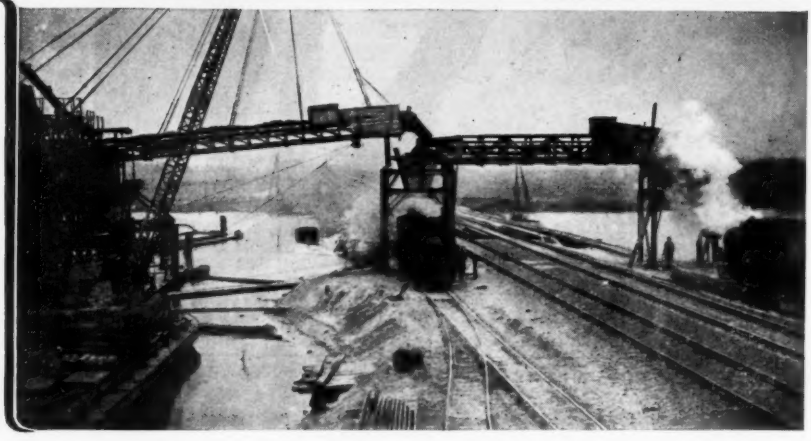

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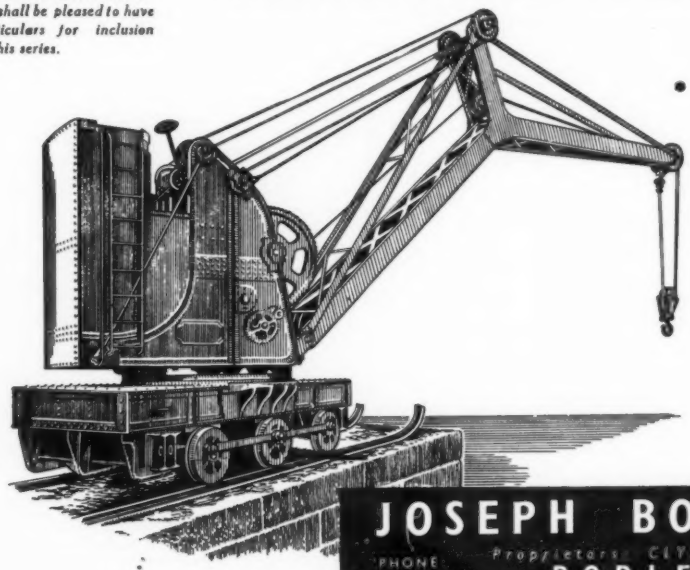

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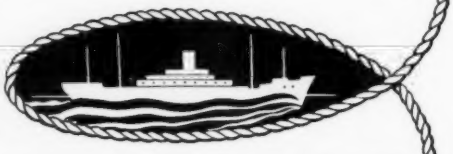

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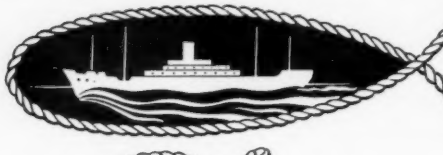

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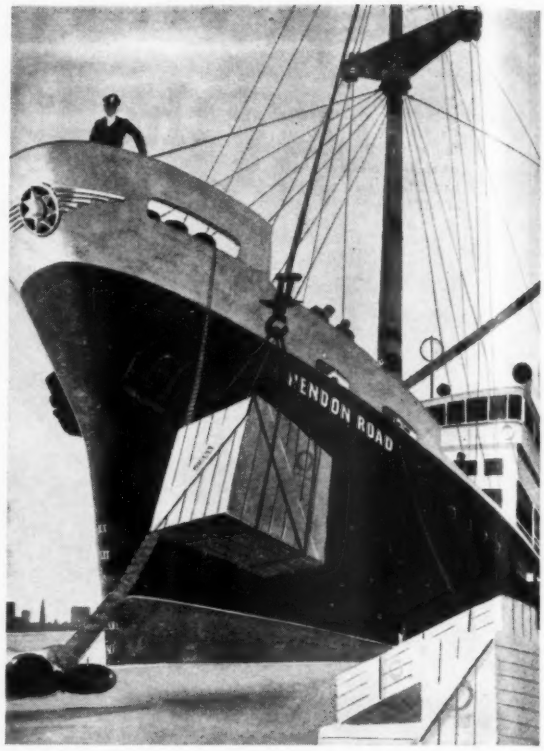

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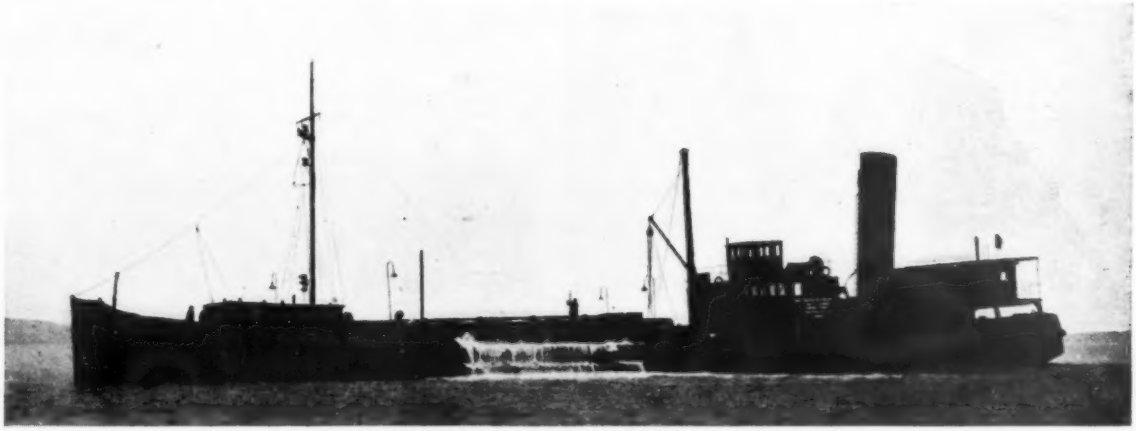

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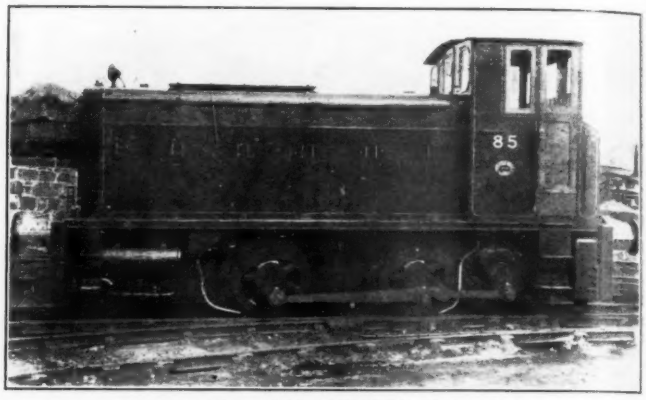

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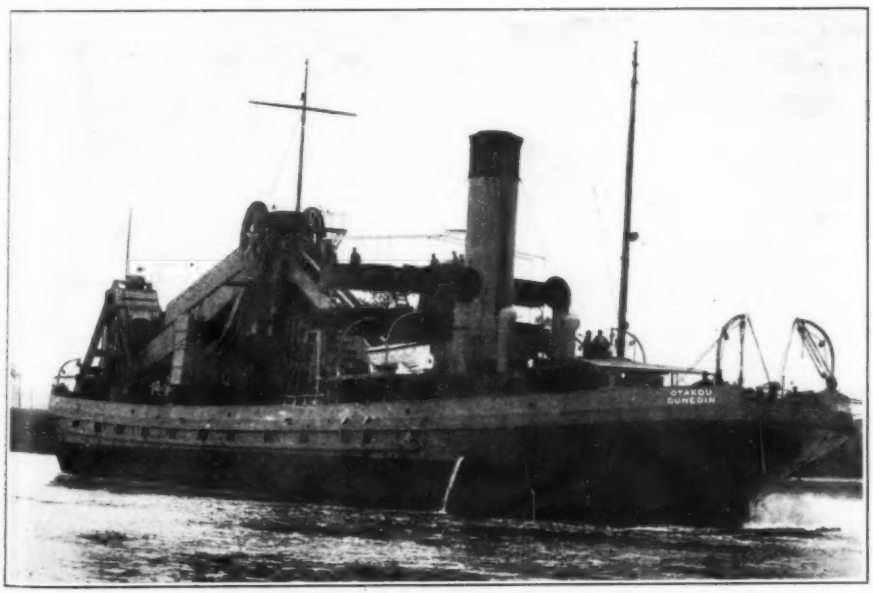

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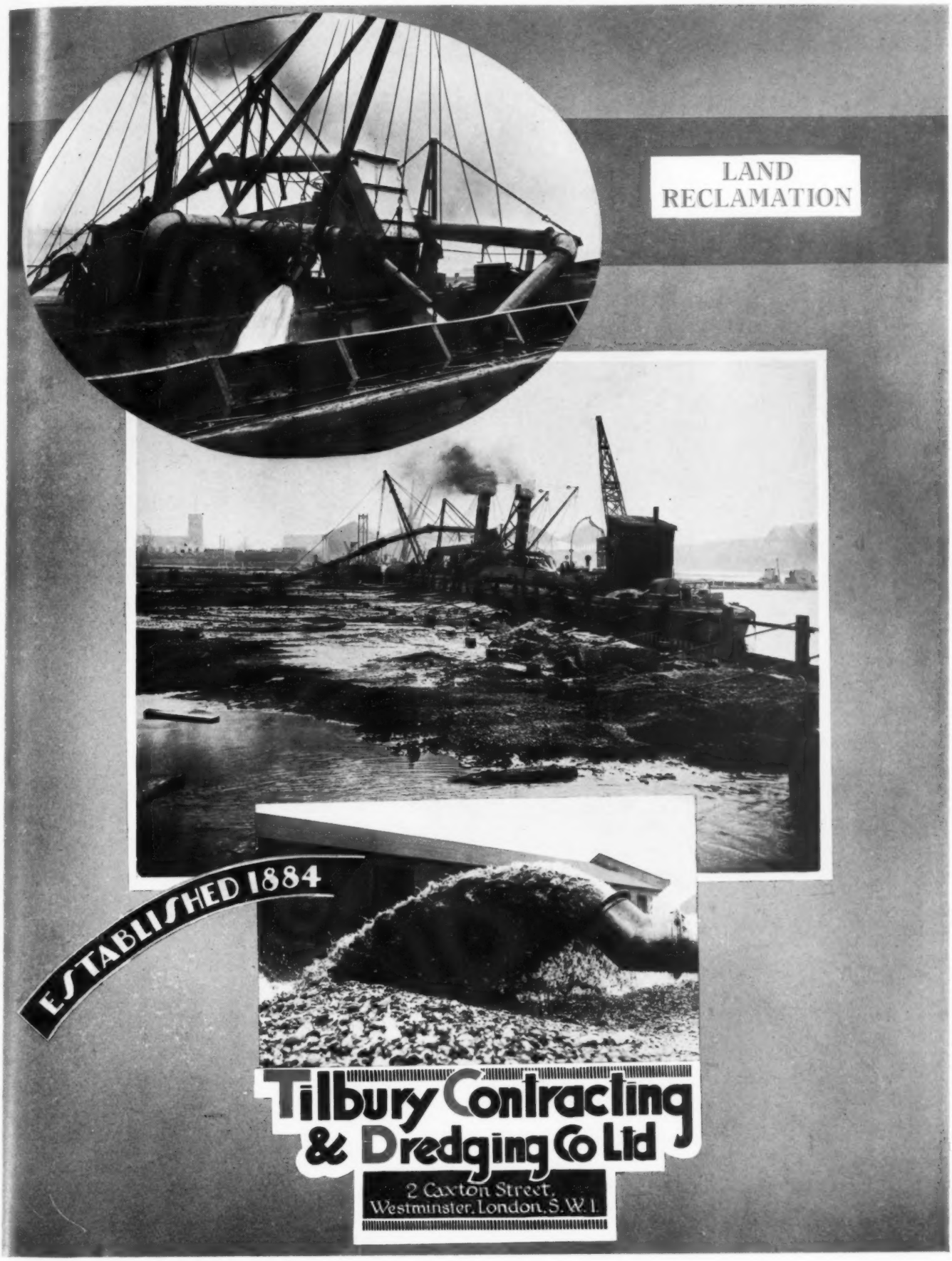
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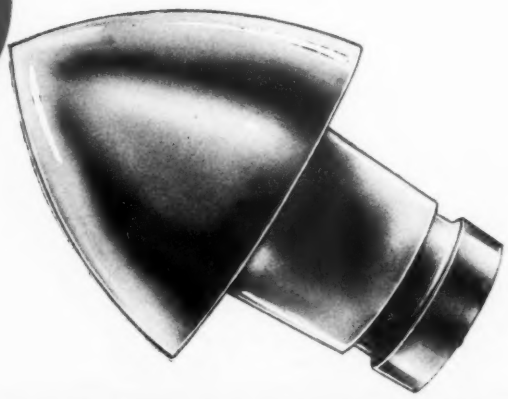

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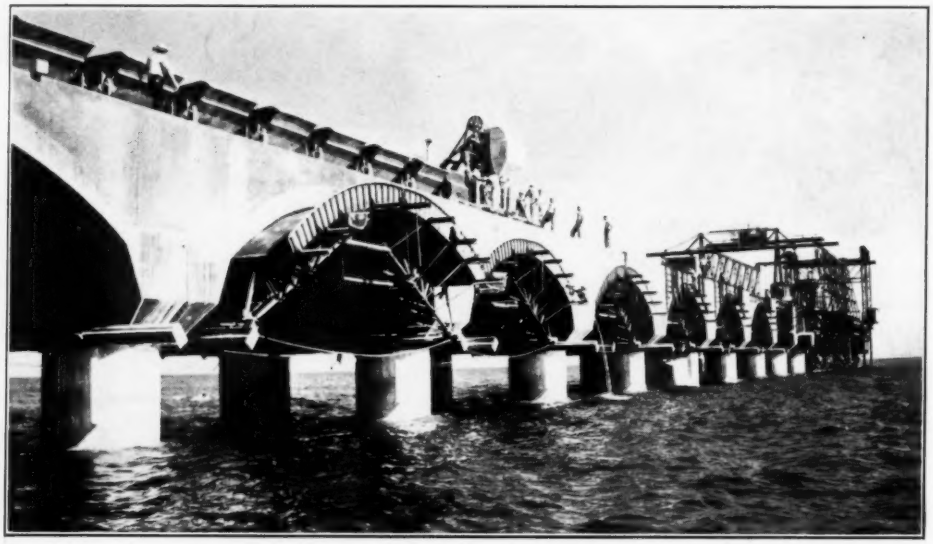

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